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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Juan Pablo di Lelle et al.	Examiner:	N/A
Serial No.:	10/817,348	Group Art Unit:	N/A
Filed:	April 2, 2004	Docket:	G&C 30566.325-US-01
Title:	THREE-DIMENSIONAL COMPOSITING		

CERTIFICATE OF MAILING OR TRANSMISSION UNDER 37 CFR 1.8

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By: Jason S. Feldmar
Name: Jason S. Feldmar

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

We are transmitting herewith the attached:

☒ Transmittal sheet, in duplicate, containing a Certificate of Mailing under 37 CFR 1.8.
☒ Certified copy of a GB application, Serial No. 03 07 582.7, filed April 2, 2003, the right of priority of which is claimed under 35 U.S.C. 119.
☒ Return postcard.

Please consider this a PETITION FOR EXTENSION OF TIME for a sufficient number of months to enter these papers, if appropriate.

Please charge all requisite fees to Deposit Account No. 50-0494 of Gates & Cooper LLP. A duplicate of this paper is enclosed.

Customer Number 22462
GATES & COOPER LLP
Howard Hughes Center
6701 Center Drive West, Suite 1050
Los Angeles, CA 90045
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By: Jason S. Feldmar
Name: Jason S. Feldmar
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By: Jason S. Feldmar
Name: Jason S. Feldmar

COMMUNICATION REGARDING PRIORITY DOCUMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Please place the following Certified Priority Document into the file of the above-identified identified patent application, as follows:

Great Britain Application No. 03 07 582.7, Filed April 2, 2003

Respectfully submitted,

GATES & COOPER LLP
Attorneys for Applicant(s)

Howard Hughes Center
6701 Center Drive West, Suite 1050
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Date: May 4, 2004

By: Jason S. Feldmar
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JSF/io

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation and Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein together with the Statement of inventorship and of right to grant of a Patent (Form 7/77), which was subsequently filed.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

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Signed M Coker

Dated 1 April 2004

Patents Form 7/77

Patents Act 1977

7/77

Statement of inven~~torship and of~~ right to grant of a patent

The Patent Office
Concept House
Cardiff Road
Newport
Gwent NP10 8QQ

1.	Your reference	2034-P589-GB
2.	Patent application number	0307582.7
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	AUTODESK CANADA INC 10 Duke Street Montreal, Quebec Canada H3C 2L7
4.	Title of the invention	Three-Dimensional Compositing
5.	State how the applicant*(s)* derived the right from the inventor*(s)* to be granted a patent	The Applicant derived the right to the invention by an agreement made with the inventors named overleaf and this agreement was confirmed in written assignments dated 24 September 2003
6.	How many, if any, additional Patents Forms 7/77 are attached to this form? *(see note (c))*	None

7. I/We believe that the person*(s)* named over the page *(and on any extra copies of this form)* is/are the inventor*(s)* of the invention which the above patent application relates to.

Signature [signature] Date **Thursday, 09 October 2003**

8. Name and daytime telephone number of person to contact in the United Kingdom — RALPH ATKINSON CPA, 0114 275 2400

Patents Form 7/77

Enter the full names, address and postcodes of the inventors in the boxes and underline the surnames

Juan Pablo <u>Di LELLE</u> 334 Terrasse St Denis Suite 304 Montréal, Quebec Canada H2X 1E8   82755 70001
Patents ADP number:

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Patents ADP number:

Patents ADP number

- 2 APR 2003

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P01/7700 0.00-0307582.7

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Request for grant of a patent
Grant

- 2 APR 2003

The Patent Office
Concept House
Cardiff Road
Newport
Gwent NP10 8QQ

1.	Your reference	2034-P589-GB
2.	Patent application number	0307582.7 NEW
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	AUTODESK CANADA INC 10 Duke Street Montréal, Quebec Canada H3C 2L7
	Patents ADP number *(if you know it)*	8378069001
	If the applicant is a corporate body, give the country/state of its incorporation	Quebec, Canada
4.	Title of the invention	THREE-DIMENSIONAL COMPOSITING
5.	Name of your agent	ATKINSON BURRINGTON
	"Address for service" in the United Kingdom to which all correspondence should be sent	25-29 President Buildings President Way Sheffield S4 7UR GB
	Telephone No:	0114 275 2400
	Patents ADP number	7807043001 ✓

		Country	Priority application number *(if you know it)*	Date of filing *(day/month/year)*
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	N/A	N/A	N/A

		Number of earlier application	Date of filing (day/month/year)
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	N/A	N/A

8.	Is a statement of inventorship and of right to grant of a patent required in support of this request?	YES

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	31
Claim(s)	03
Abstract	01
Drawings	18 + 18

10. If you are also filing any of the following, state how many against each item.

Priority documents	N/A
Translations of priority documents	N/A
Statement of inventorship and right to grant of a patent (*Patents Form 7/77*)	NONE
Request for preliminary examination and search (*Patents Form 9/77*)	NONE
Request for substantive examination (*Patents Form 10/77*)	NONE
Any other documents (*Please specify*)	

11. I/We request the grant of a patent on the basis of this application.

Signature Date **Tuesday, 01 April 2003**

12. Name and daytime telephone number of person to contact in the United Kingdom

RALPH ATKINSON CPA
0114 275 2400

SR-04-002

DUPLICATE

Three-Dimensional Compositing

Background of the Invention

1. Field of the Invention

The present invention relates to processing image frames for the compositing thereof. More particular, the present invention relates to positioning said image frames within a compositing volume for the compositing thereof.

2. Description of the Related Art

Systems for processing image data, having a processing unit, storage devices, a display device and manually-operable devices (such as a stylus and touch-tablet combination) are shown in United States Patent 5,892,506, 5,786,824 and 6,269,180 all assigned to the present Assignee. In these aforesaid systems, it is possible to perform many processing functions upon stored image data in response to an artist manually selecting said functions by means of said input devices.

Most such systems according to the known prior art provide an artist with a two-dimensional compositing environment, wherein interaction with said image data is constrained to the X,Y screen co-ordinate system because said image data is traditionally two-dimensional image frames captured and digitized from field. Within this context, compositing involves for instance the keying of a foreground frame portraying talent filmed against a blue or green saturated background with a background frame portraying an alternative environment or location, in order to replace said blue or green environment with said alternative location in a final composite frame. Such a composite frame may at times involve many superimposed foreground and background

frames, whereby each of said image frames is defined as a discreet layer of a figurative stack of layers representing the totality of said foreground and background frames, such that said artist may effectively identify, select and interact with each such discreet layer, thus overcoming the lack of a third z-dimension of the compositing environment.

Recently, in such systems as "Toxiç" licensed by the present Assignee, the traditional 2-D compositing environment has been replaced with a three-dimensional compositing volume defined by a X,Y,Z canonical co-ordinate system in order to facilitate the interaction of said artist with the depth of a stack of foreground and background image frames. Moreover, film editing increasingly requires said artists to not only composite image frames but also computer-generated three-dimensional objects are characters in a final composite frame.

An important problem has however arisen form this dimensional paradigm shift, in that although three-dimensional object modelling and animation techniques have long been performed in systems such as "3-DS MAX" licensed by the present Assignee, such techniques require a skill set substantially different from the skill set of a compositing artist long-used to work within a two dimensional environment.

More particularly, such compositing artists are used to manipulating image frames by means of a X,Y two-dimensional translation only in a 2-D compositing environment, whereas manipulation of such image frames in a three-dimensional compositing environment now involves further transformations such as rotation, scaling and shearing. With regard to the number of distinct image layers required in modern film compositing, the respective positioning of each of said layers having to be precisely positioned relative to one another can become a time sink if the compositing artist lacks

the required three-dimensional manipulation skills that are part of the 3-D artist skill set. What is therefore required is an apparatus and method for simplifying the positioning of image frames within such three-dimensional compositing environment.

Brief Summary of the Invention

According to an aspect of the present invention, there is provided an apparatus for generating image data comprising memory means, display means, user input means and processing means, wherein said memory means stores said image data and instructions and said instructions configure said processing means to perform the steps of: defining first image data as a first layer having respective co-ordinates within a three-dimensional volume configured with a reference co-ordinate system; upon selecting second image data as a second layer to composite with said first layer, generating a reference pose layer and configuring the co-ordinates thereof as a second reference co-ordinate system within said volume; positioning said reference pose layer relative to said first layer; and defining said second image data as said second layer having respective co-ordinates within said three-dimensional volume configured with said second reference co-ordinate system.

According to a second aspect of the present invention, there is provided a method of generating image data comprising an apparatus for generating image data comprising memory means, display means, user input means and processing means, wherein said memory means stores said image data and instructions and said instructions configure said processing means to perform the steps of: defining first image data as a first layer having respective co-ordinates within a three-dimensional volume

configured with a reference co-ordinate system; upon selecting second image data as a second layer to composite with said first layer, generating a reference pose layer and configuring the co-ordinates thereof as a second reference co-ordinate system within said volume; positioning said reference pose layer relative to said first layer; and defining said second image data as said second layer having respective co-ordinates within said three-dimensional volume configured with said second reference co-ordinate system.

Brief Description of the Several Views of the Drawings

Figure 1 shows a computer editing system, including a computer system video display unit and a broadcast-quality monitor;

Figure 2 details the typical hardware components of the computer editing system shown in *Figure 1*;

Figure 3 shows a volume having a canonical reference co-ordinate system and objects therein having respective canonical reference co-ordinate systems;

Figure 4 details the operational steps according to which the artist shown in *Figure 1* may operate the system shown in *Figures 1* and *2* according to the present invention, including a step of loading a set of instructions and a step of starting the processing thereof;

Figure 5 shows the contents of the memory shown in *Figure 2* subsequently to the loading step shown in *Figure 4*;

Figure 6 details the initialization of three-dimensional transformation functions in the starting step shown in *Figure 4*;

Figure 7 illustrates a three-dimensional compositing volume output by the application shown in *Figure 5* to a display device shown in *Figure 1*;

Figure 8 details the processing steps according to which the application shown in *Figures 4* to *7* processes a scene graph upon the selection thereof shown in *Figure 4*;

Figure 9 provides an example of a scene graph shown in *Figures 5* and *8*;

Figure 10 illustrates the compositing volume shown in *Figure 7* including scene objects shown in *Figures 8* and *9*;

Figure 11 shows the environment shown in *Figure 10*, wherein the artist shown in *Figure 1* manipulates a foreground image frame as a new layer according to the known prior art;

Figure 12 details the operational steps according to which the artist shown in *Figure 1* edits the image data shown in *Figures 9* and *10* according to the present invention, including steps of generating and positioning a reference pose layer and steps of generating and positioning a new layer;

Figure 13 further details the operational steps according to which the reference pose layer shown in *Figure 12* is generated;

Figure 14 further details the operational steps according to which the reference pose layer shown in *Figures 12* and *13* is positioned by the user shown in *Figure 1*;

Figure 15 further details the operational steps according to which the new layer shown in *Figure 12* is generated;

Figure 16 further details the operational steps according to which the new layer shown in *Figures 12* and *15* is positioned by the user shown in *Figure 1*;

Figure 17 shows the scene graph described in *Figure 9* wherein a reference pose layer and a new layer shown in *Figures 12* to *16* have been inserted;

Figure 18 illustrates the compositing volume shown in *Figure 10* including a reference pose layer shown in *Figures 12* to *17* and a new layer manipulated by the artist shown in *Figure 1* according to the present invention.

Written Description of the Best Mode for Carrying Out the Invention

Figure 1

A computer editing system, including a computer system video display unit and a high-resolution monitor, is shown in *Figure 1*.

In the system shown in *Figure 1*, instructions are executed upon a graphics workstation operated by a compositing artist **100**, the architecture and components of which depends upon the level of processing required and the size of images being considered. Examples of graphics-based processing systems that may be used for very-high-resolution work include an ONYX II manufactured by Silicon Graphics Inc, or a multiprocessor workstation **101** manufactured by IBM Inc. The processing system **101** receives instructions from an artist by means of a stylus **102** applied to a touch tablet **103**, in response to visual information received by means of a visual display unit **104**. In addition, data may be supplied by said artist via a keyboard **105** or a mouse **106**, with input source material being received via a real-time digital video recorder or similar equipment configured to supply high-bandwidth frame data.

The processing system **101** includes internal volatile memory in addition to bulk, randomly-accessible storage, which is provided by means of a RAID disk array **107**, also known as a framestore. Output material may also be viewed by means of a high-quality broadcast monitor **108**. System **101** includes an optical data-carrying medium reader **109** to allow executable

instructions to be read from a removable data-carrying medium in the form of an optical disk **110**, for instance a DVD-ROM. In this way, executable instructions are installed on the computer system for subsequent execution by the system. System **101** also includes a magnetic data-carrying medium reader **111** to allow object properties and data to be written to or read from a removable data-carrying medium in the form of a magnetic disk **112**, for instance a floppy-disk or a ZIP ™ disk.

Figure 2

The components of computer system **101** are further detailed in *Figure 2* and, in the preferred embodiment of the present invention, said components are based upon Intel® E7505 hub-based Chipset.

The system includes two Intel® Pentium™ Xeon™ DP central processing units (CPU) **201**, **202** running at three Gigahertz, which fetch and execute instructions and manipulate data with using Intel®'s Hyper Threading Technology via an Intel® E7505 533 Megahertz system bus **203** providing connectivity with a Memory Controller Hub (MCH) **204**. CPUs **201**, **202** are configured with respective high-speed caches **205**, **206** comprising at least five hundred and twelve kilobytes, which store frequently-accessed instructions and data to reduce fetching operations from a larger memory **207** via MCH **204**. The MCH **204** thus co-ordinates data flow with a larger, dual-channel double-data rate main memory **207**, which is between two and four gigabytes in data storage capacity and stores executable programs which, along with data, are received via said bus **203** from a hard disk drive **208** providing non-volatile bulk storage of instructions and data via an Input/Output Controller Hub (ICH) **209**. Said ICH **209** similarly provides connectivity to DVD-ROM re-writer **109** and ZIP™ drive **111**, both of which

read and write data and instructions from and to removable data storage media. Finally, ICH **209** provides connectivity to USB 2.0 input/output sockets, to which the stylus **102** and tablet **103** combination, keyboard 105 and mouse **106** are connected, all of which send user input data to system **101**.

A graphics card **211** receives graphics data from CPUs **201**, **202** along with graphics instructions via MCH **204**. Said graphics accelerator **211** is preferably coupled to the MCH **204** by means of a direct port **212**, such as the direct-attached advanced graphics port 8X (AGP 8X) promulgated by the Intel® Corporation, the bandwidth of which exceeds the bandwidth of bus **203**. Preferably, the graphics card **211** includes substantial dedicated graphical processing capabilities, so that the CPUs **201**, **202** are not burdened with computationally intensive tasks for which they are not optimised.

Network card **213** provides connectivity to the framestore **107** by processing a plurality of communication protocols, for instance a communication protocol suitable to encode and send and/or receive and decode packets of data over a Gigabit-Ethernet local area network. A sound card **214** is provided which receives sound data from the CPUs **201**, **202** along with sound processing instructions, in a manner similar to graphics card **211**. Preferably, the sound card **214** includes substantial dedicated digital sound processing capabilities, so that the CPUs **201**, **202** are not burdened with computationally intensive tasks for which they are not optimised. Preferably, network card **213** and sound card **214** exchange data with CPUs **201**, **202** over system bus **203** by means of Intel®'s PCI-X controller hub **215** administered by MCH **204**.

The equipment shown in *Figure 2* constitutes a typical graphics

workstation comparable to a high-end IBM™ PC compatible or Apple™ Macintosh.

Figure 3

A plurality of reference co-ordinate systems (RCS) are described in *Figure 3*.

A first two-dimensional reference co-ordinate system **301** is known to those skilled in the art as "screen space", RCS **301** for instance corresponds to the two-dimensional display of VDU **104**, whereby a third dimension (Z) would extend away from the screen display of said VDU **104** towards artist **103**. Traditionally compositing environments conform to RCS **301**, wherein any output image data may only be manipulated to the X and Y dimension, whereby the origin **302** of RCS **301** acts as the translation reference centre for any two-dimensional objects manipulated therein. A canonical reference co-ordinate system **303** is shown having a third dimension (Z) **304**, the origin **305** of which acts as the reference transformation centre for any three-dimensional object manipulated therein. Within RCS **305**, two-dimensional objects such as an image frame may now be scaled, for instance if they are manipulated away or towards the X or Y segment in the Z **304** dimension. RCS **305** is traditionally referred to by those skilled in the art as the "world space".

A two-dimensional image frame **306** is shown within RCS **305** as a four-sided polygon, one joint **307** of which has X **308**, Y **309** and Z **310** co-ordinates within RCS **305**. The third dimension **304** of RCS **305** allows for the rotation of image frame **306** about its segment **311** for instance.

A third canonical reference co-ordinate system **312** is shown, the original **303** of which is defined as the geometrical centre of the three-

dimensional object defined by image frame **306**. In the example, said geometrical centre is the intersection of the diagonals respectively extending from the top left to the bottom right corner and top right to the bottom left corner of polygon **306** and the notion of geometrical centre is well known to those skilled in the art for three-dimensional objects also having a volume. RCS **313** is known to those skilled in the art as "local space" RCS. That is, the origin **313** is the reference transformation centre for processing manipulation of polygon **306** independently of RCS **305**. For instance, polygon **306** may be rotated about the X axis, the Y axis, the Z axis or a combination thereof relative to origin **313**, the respective X,Y,Z co-ordinates of which would remain unchanged relative to RCS **305**.

A second image frame **314** is shown as a four-sided polygon, a corner **315** of which has respective X **316**, Y **317** and Z **318** co-ordinates within RCS **312**. In this instance, although RCS **312** is the local RCS of image frame **316**, it is known as the "parent" RCS of image frame **314**. Thus, any transformation applied to image frame **306** as a polygon is propagated to image frame **314**, for instance if polygon **306** is scaled up (e.g. enlarged), having the effect of scaling up the X **316**, Y **317** and Z **318** of joint **315**. In three-dimensional modelling terms, image frame **314** is known as a child of image frame **306**, but this does not preclude image frame **314** of having its own geometrical centre (not shown) which has respective X,Y,Z co-ordinates in screen space RCS **301**, world RCS **303** and parent RCS **312**.

The difficulty for compositing artists results from the fact that, irrespective of whether the compositing environment is two-dimensional or three-dimensional, the notion of parent and children object in three-dimensional modelling differs at times substantially from the notion of

parent and children objects in image compositing and this difference will be further described below.

Figure 4

The processing steps according to which artists **103** may operate the image processing system shown in *Figure 1* are described in *Figure 4*. At step **401**, artist **100** switches on the image processing system and, at step **402**, an instruction set is loaded from hard disk drive **208**, DVD ROM **110** by means of the optical reading device **109** or the magnetic disk **112** by means of magnetic reading device **111** or even a network server access by means of network card **213**.

Upon completing the loading of step **402** into memory **207**, CPUs **201**, **202** may start processing said set of instructions, also known as an application, at step **403**. User **103** may then select a scene graph at step **404**, details of which will be described further below. Upon performing the selection of step **404**, artist **100** may now perform a variety of processing functions upon the image data of the scene graph at step **405**, whereby a final composite image frame may then output at step **406** by means of rendering the edited scene.

At step **407**, a question is asked as to whether the image data of another scene requires editing at step **405** and rendering at step **406**. If the question of step **407** is answered positively, control is returned to step **404**, whereby another scene may then be selected. Alternatively, if the question of **407** is answered negatively, signifying that artist **100** does not require the functionality of the application loaded at step **402** anymore and can therefore terminate the processing thereof at step **408**. Artist **100** is then at liberty to switch off the image processing system **101** at step **409**.

Figure 5

The contents of main memory **207** subsequently to the selection step **404** of a scene are further detailed in *Figure 5*.

An operating system is shown at **501** which comprises a reduced set of instructions for CPUs **201**, **202** the purpose of which is to provide image processing system **101** with basic functionality. Examples of basic functions include for instance access to files stored on hard disk drive **208** or DVD/CD-ROM **110** or ZIP(tm) disk **112** and management thereof, network connectivity with a network server and frame store **107**, interpretation and processing of the input from keyboard **105**, mouse **106** or graphic tablet **102**, **103**. In the example, the operating system is Windows XP(tm) provided by the Microsoft corporation of Redmond, California, but it will be apparent to those skilled in the art that the instructions according to the present invention may be easily adapted to function under different other known operating systems, such as IRIX(tm) provided by Silicon Graphics Inc or LINUX, which is freely distributed.

An application is shown at **502** which comprises the instructions loaded at step **402** that enable the image processing system **101** to perform steps **403** to **407** according to the invention within a specific graphical user interface displayed on VDU **104**. Application data is shown at **503** and **504** and comprises various sets of user input-dependent data and user input-independent data according to which the application shown at **502** processes image data. Said application data primarily includes a data structure **503**, which references the entire processing history of the image data as loaded at step **404** and will hereinafter be referred to as a scene graph. According to the present invention, scene structure **503** includes a

scene hierarchy which comprehensively defines the dependencies between each component within an image frame as hierarchically-structured data processing nodes, as will be further described hereinbelow.

Scene structure **503** comprises a plurality of node types **505**, each of which provides a specific functionality in the overall task of rendering a scene according to step **406**. Said node types **505** are structured according to a hierarchy **506**, which may preferably but not necessarily take the form of a database, the purpose of which is to reference the order in which various node types **505** process scene data **504**. Scene structure **503** also temporarily comprises the reference pose layers **507** of the present invention when they are generated and used by artist **100**.

Further to the scene structure **503**, application data also includes scene data **504** to be processed according to the above hierarchy **503** in order to generate one or a plurality of image frames, i.e. the parameters and data which, when processed by their respective data processing nodes, generate the various components of a final composite image frame.

A number of examples of scene data **504** are provided for illustrative purposes only and it will be readily apparent to those skilled in the art that the subset described is here limited only for the purpose of clarity. Said scene data **504** may include image frames **508** acquired from framestore **107**, for instance a background image frame digitised from film and subsequently stored in frame store **107**, portraying a TV set and a foreground image frame digitised from film and subsequently stored in frame store 107, portraying a TV presenter.

Said scene data **504** may also include audio files **509** such as musical score or voice acting for the scene structure selected at step **404**. Said scene data **504** may also include pre-designed three-dimensional

models **510**, such as a camera object required to represent the pose of the rendering origin and frustrum of a rendering node within the compositing environment, which will be described further below in the present description. In the example, scene data **804** includes lightmaps **811**, the purpose of which is to reduce the computational overhead of CPUs **201**, **202** when rendering the scene with artificial light sources. Scene data **804** finally include three-dimensional location references **811**, the purpose of which is to reference the position of the scene objects edited at step **405** within the three-dimensional volume of the scene compositing environment.

Figure 6

In order to manipulate the various scene objects **508** to **513** within a three-dimensional compositing environment and manipulates said objects therein, application **502** must initialize three-dimensional transformation functions and respect reference co-ordinate systems and said initialization is performed when CPUs **201**, **202** start processing said application at step **403** and further described in *Figure 6*.

At step **601**, application **502** first initilializes a three-dimensional transform matrix M (X, Y, Z). In the preferred embodiment of the present invention, said matrix M is the concatenation **602** of a plurality of specific geometric transformation matrices including a rotation transform matrix MR **603**, a translation matrix transform matrix MT **604**, a scaling transformation matrix MS1 **605** and a sheer transformation matrix MS2 **606**.

Said matrices **602** to **606** are preferably 4 x 4 transformation matrices but, in an alternative embodiment of the present invention, said matrices are 3 x 3 transformation matrices. Irrespective of the number of factors of said matrices, matrices MR, MT, MS1 and MS2 are standard

three-dimensional transformation matrices and may transform a three-dimensional object in relation to any three-dimensional RCS. Consequently, at step **607**, application **502** next initlializes RCS transform condition in order to define the various conformation matrices applied to the pose of a three-dimensional object, depending upon the RTS chosen as its centre of its transformation. The pose of an object may be defined as its rotation, translation, scaling and/or sheer transformation values at any given time in relation to an RCS.

Conformation matrices are pre-set three-dimensional transform matrices Mn translating the pose of a three-dimensional object from a given RCS to another.

In the preferred embodiment of the present invention, application **502** defines a 3-D compositing environment configurable with four RCS, but it will be easily understood by those skilled in the art that the functionality of the present invention is not limited thereto and that many more discreet RCS may be implemented.

Thus, the world RCS is generated as the default RCS of the 3-D compositing volume and a first conformation matrix M1 is declared for transforming world pose value to the screen RCS at **609**. Similarly, a second conformation matrix M2 is declared for transforming world pose values at **610** or screen pose values at **611** to the parent RCS. Likewise, a third conformation matrix M33 is declared to conform world pose values at **612**, screen pose values at **613** and parent pose values at **614** to the local RCS. Upon completing steps **601** and **607**, application **502** may now output a representation of the initialized 3-D compositing environment and three-dimensional objects **508** to **513** therein in a graphical user interface.

Figure 7

A representation of the graphical user interface of application **502** is shown in *Figure 7* which includes a three-dimensional compositing environment having an image frame therein and a plurality of user-operable representations of processing functions known to those skilled in the art as widgets.

VDU **104** is shown, the display of which is configured with a compositing environment display portion **701** and a function selection display portion **702**. The origin **302** of the screen space of compositing environment is the bottom-left corner of display portion **701** but the compositing environment therein is defined as a volume having a world RCS **303** configured with an origin **305**. The artist **100** operating image processing system **101** is therefore intuitively aware of the third dimension **304** of the three-dimensional compositing environment. The image frame **306** is shown within said environment as a four-sided polygon having a local RCS **312**, the origin **313** of which has respective X **703**, Y **704** and Z **705** co-ordinates in the world RCS **304**.

Within the function selection portion **702**, a first area **706** provides four user-operable widgets **707** to **710** which, when individually selected by the user by means of a pointer **711**, respectively let said user select the screen RCS, world RCS, parent RCS or local RCS as the reference transformation centre. In the preferred embodiment of the present invention, said pointer **711** is translated across the display of VDU **104** within portion **701** or portion **702** by means of the two-dimensional planar movement applied by the artist to mouse **106** or stylus **102** on tablet **103** and operates selection of three-dimensional objects within said portion **701** or activation of widgets within said portion **702** by means of conventional

dragging and/or clicking.

Within said portion **702**, a second area **712** displays the respective X, Y and Z co-ordinates of the geometric centre of the three-dimensional objects or group thereof currently selected in relation to the RCS currently selected. In the example, the user selects image frame **306** with pointer **711**, having selected the world RCS, whereby the X **703**, Y **704** and Z **705** co-ordinates of its geometric centre which is also the origin **313** of its local RCS are displayed in portion **712**.

A third portion **713** is configured with three user-operable widgets **714** to **716**, wherein user selection of the object widget **714** instructs application **502** to output detailed object characteristics, for instance in the form of a pop-up window superimposed over portion **701**, portion **702** or a combination thereof. User selection of layer widget **715** instructs application **502** to generate a new layer object according to the present invention and, similarly, user selection of tool widget **716** instructs application **502** to generate a new tool layer, within the compositing environment shown in portion **701**.

Figure 8

The image frame **306** is described within the graphical user interface of application **502** for the purpose of illustrating multiple RCS within the context of a compositing environment as described in *Figure 3*, whereby upon completing the application starting step **403**, the graphical user interface of application **502** only contains an empty 3-D compositing environment within display portion **701**. The artist should preferably select a scene graph at the next step **404**, which is further described in *Figure 8*.

At step **801**, the artist selects a scene graph comprising a scene

structure **503** and scene data **504**, which are for instance stored in frame store **107** and subsequently loaded into main memory **207** at step **801**. At Step **802**, application **502** processes the hierarchies defined by the scene structure **503** in order to populate the database **506** with references derived from node types **505** and the scene data **504** each of said referenced nodes respectively processes and output. At step **803**, application **502** selects a first node in the order specified by said database **506** in order to generate a displayable three-dimensional object therefrom to be eventually located and displayed within the compositing environment shown at step **701**. Thus, application **502** first processes said node objects to derive its geometrical centre and the three-dimensional co-ordinates thereof in relation to the default RCS **304** at step **804**.

At step **805**, the question is asked as to whether said selected node has a parent node. In effect, application **502** looks up database **506** and the hierarchy referenced therein to answer question **805**, whereby if said question is answered positively, the world RCS co-ordinate of the child node are transformed with conformation matrix **610** at step **806** into three-dimensional co-ordinates in the parent RCS (e.g. RCS **312** in *Figure 3*) of its parent node. Alternatively, the question of step **805** is answered negatively, whereby it is determined at step **807** that the reference co-ordinate system in relation to which the object generated at step **803** should be located is the default world RCS **304**. Consequently, the 3-D object is located by means of its geometrical centre 3-D co-ordinates in relation to a world RCS **304** or its parent RCS and displayed within 3-D compositing environment shown at **701** at step **808**.

At step **809**, a second question is asked as to whether another node remains to be processed according to steps **803** to **808**. If the question of

step **809** is answered positively, the node reference counter is incremented at step **810** and control is subsequently returned to step **803**, whereby said next node may be selected, its geometrical centre derived, its relationship to eventual parent node assessed and so on and so forth. Alternatively, the question of step **809** is answered negatively, signifying that all the nodes of the scene graph loaded at step **801** have been processed and their respective three-dimensional objects are represented within the three-dimensional compositing environment such that the artist may then edit any or all of said objects at the next step **405**.

Figure 9

An example of the scene graph loaded at step **801** is illustrated in *Figure 9*.

In three-dimensional compositing applications such as application **502**, the hierarchy of data processing nodes is traditionally represented as a top-down tree structure, wherein the topmost node **901** pulls all the data output by nodes depending therefrom in order to output final output data, some of which will be image data and some of which may be audio data, for instance generated by a first child node **902**. In order to generate image data, a fundamental requirement is the positioning of a "rendering" camera and the definition of its view frustrum, as defined by rendering a node **903**. Indeed, the purpose of a compositing application remains to output a two-dimensional, final composite image frame.

Transposing the traditional 2-D compositing of background and foreground frames such as TV set background **508** generated by node **904** into the third dimension therefore involves the concurrent manipulation and positioning of the 3-D representation of such an image frame as a flat plane

and the 3-D representation of the camera and its frustrum within a volume. In the example if the R,G,B colour component values of said image frame **508** require correction before said frame is rendered, an additional colour-correction node **905** pulls the image data output by frame node **904** in order to process it and effect said correction before rendering node **903** can render said colour-corrected frame **508**.

The scene graph shown in *Figure 9* is very small is so restricted for the purpose of not obscuring the present description but it will be readily apparent to those skilled in the art that such scene graphs usually involve hundreds or even thousands of such hierarchical data processing nodes.

Figure 10

The respective 3-D objects generated by application **502** within the 3-D compositing environment shown at **701** according to step **404** are illustrated within the graphical user interface of application **502** in *Figure 10*.

A stylised camera object **1001** is first generated within the 3-D compositing environment and is located therein by means of its geometrical centre (not shown) in relation to world RCS **304**, because node **901** cannot be represented within said environment, thus said camera object **1001** has no parent. The artist may however select said camera object with point **711** and manipulate said object within portion **701** in order relocate object **1001** within the environment, whereby various 2-D input processing algorithms well known to those skilled in the art may process the X, Y two-dimensional input imparted by means of mouse **106** or stylus and tablet **102**, **103** in order to effect said manipulation in relation to the world origin **305**, i.e. modify the X, Y and Z co-ordinates of the geometrical centre of object **1001**.

Alternatively, the artist may select widget **707**, whereby the co-ordinates of the geometrical centre of object **1001** are transformed by conformation **609** such that 2-D input only translates the camera object **1001** in relation to origin **302**. If artist **100** selects widget **710**, however, the geometrical centre (not shown) of camera object **1001** becomes the RCS, e.g. the world RCS co-ordinates of object **1001** are conformed by conformation matrix **612** or, if the artist subsequently selected the screen RCS as previously described, the screen co-ordinates of said geometrical centre are conformed by conformation matrix **613**, such that said 2-D input is processed to impart manipulation of object **1001** about its geometrical centre only.

A second 3-D object **1001** is displayed within portion **701** representing the image frame output of node **904**, which is a four-sided polygon having frame **508** mapped thereto as a polygon texture and has no depth. Node **904** is a child of rendering node **903**, hence it is located within world **304** by means of transforming the world RCS co-ordinate values of its geometrical centre **1003** according to step **806**, i.e. conforming its world co-ordinate values with conformation matrix **610**. However, upon the artist selecting widget **710** will result in yet again conforming the 3-D co-ordinates of geometric centre **1003** first conformed at **806** with conformation matrix **614**, whereby said artist may now manipulate said object **1002** relative to the origin **1004** of its local RCS **1005**. In accordance with the description of the present invention, however, any interaction locally imparted upon object **1002** will not be propagated to camera object **1001**. Conversely, however, any interaction imparted to camera object **1001** will be propagated to image frame object **1002**. For instance, selecting the screen RCS and selecting the camera object **1001**, then dragging camera object **1001** towards the

right of the screen will similarly drag object **1002** towards the right of the screen, because object **1002** is a child of object **1001**.

Figure 11

Within the context of the description of *Figure 10*, the difference between the hierarchies of nodes-objects in 3-D modelling and/or animation and image frame compositing is shown in *Figure 11*, wherein an artist creates a new frame node, thus its corresponding 3-D object, according to the known prior art.

Camera object **1001** and image frame object **1002** are shown in display portion **701** within the 3-D compositing environment, wherein object **1002** is a background frame portraying a TV set. In the example, the artist creates a new frame node outputting an image frame portraying a TV presenter as a child of rendering node **903**. It is preferred that said presenter is composited on the display area of the TV set portrayed in the image frame output by image node **904**.

In 2-D compositing environment, the task of precisely aligning the background TV set image frame with the foreground presenter image frame would be relatively simple in that said foreground TV presenter TV frame would be generated as a new layer to be simply aligned onto the target resolution-rendering rectangle (i.e. the NTSC example above) by means of a two-dimensional X, Y translation.

In 3-D compositing environments according to the known prior art, said foreground presenter image frame is generated within the compositing volume as a 3-D object **1101** having a geometrical centre **1102** and located arbitrarily within said volume, within close proximity of object **1002** or not. Whilst it would be a relatively simple task for an experienced 3-D artist to

perform the required alignment of object **1101** with object **1002** in respect of the frustrum of camera object **1001**, because such an artist is skilled in the art of rotating, translating, scaling and shearing three-dimensional objects within a volume, it is comparitively difficult for a compositing artist used to two-dimensional translation manipulation only.

Having regard to the respective poses of object **1101** and **1002** shown in *Figure 11*, precisely aligning the foreground frame **1101** with the background frame **1002** would require the compositing artist to first select object **1101**, then select the screen RCS in order to translate said object **1101** towards object **1002**; then select the local RCS to rotate object **1101** about its geometrical centre **1102** in order to achieve a pose identical to the pose of object **1002**; if required, select the world RCS in order to adjust the depth co-ordinate of object **1101** to ensure that it is positioned in front (as the foreground image frame) of object **1002**, but close enough to said object **1002** within the frustrum of camera object **1001** in order to avoid out-of-focus artefacts. Given the ever-increasing size of such image frames, especially movie image frame which can reach upto 16,000 x 16,000 pixels, such a precise alignment within a three-dimensional compositing environment is not a trivial task for the 2-D compositing artist used to two-dimensional translation only.

Having regard to the previously-stated difference in hierarchies, the above problem is compounded by the fact that, although artist **100** may want object **1101** to be a child of object **1002** in 3-D modelling terms to simplify the positioning task (because object **1101** would be positioned relative to object **1002** by means of the geometric center of said object **1002** becoming the parent RCS of said object **1101**), artist **100** may not however want object **1101** to be a child of object **1002** in compositing

terms, because the various image processing functions performed upon the frame data represented as object **1101** should not be applied to the frame data represented as object **1002**.

Figure 12

The present invention solves the problem introduced and further described in *Figure 11* by providing reference pose layers which act as positioning guides within the three-dimensional compositing environment with which to precisely position and orient a new object such as image frame **1101** by means of simple two-dimensional translation. Preferably, such guides are generated whenever an artist edits image data at step **405**, which is further described according to the present invention in *Figure 12*.

At **1201**, an artist operating processing system **101** configured to the present invention selects a scene object or group thereof, such as TV set image frame object **1002**. A first question is asked at step **1202**, as to whether a new layer, e.g. a three-dimensional object, is required. If the question of step **1202** is answered positively, as would be the case if the artist wants to generate the foreground image frame object **1101**, a second question is asked at step **1203** as to whether a referenced pose layer is required. If the question of step **1203** is answered positively, application **502** generates a referenced pose layer, or guide layer at step **1204** as a 3-D object within display portion **701**, but which does not contribute to the final output composite image frame rendered by rendering node **903**-camera object **1001**. Said artist may interact with said guide within display portion **701** by means of pointer **711** at step **1205** until such time as the guide positioning is satisfactory for the purpose at hand and the new layer required at step **1202** is subsequently generated at step **1206**.

Alternatively, the question of step **1203** is answered negatively, for instance if the compositing artist has become sufficiently proficient with three-dimensional manipulation not to require the guide of the present invention anymore or if the task at hand does not require the precision afforded by said guide, whereby control is directly forwarded to step **1206**. Upon generating said new required layer at said step **1206**, the artist may now position said new layer relative to said guide if a guide was generated according to step **1204** or relative to the scene object selected at step **1201** at the next step **1207**.

Figure 13

The step **1204** of generating the guide layer of the present invention is further described in *Figure 13.*

At step **1301**, the artist selects the guide tool within the function representation portion **702** of the graphical user interface of application **502**, either by means of point **711** activated by user interaction of mouse **106** or stylus **102** and tablet **103**, or a specific key of keyboard **105**, known to those skilled in the art as a "hot key". At step **1302**, a guide node is created as a temporary child of the scene graph node, the 3-D object representation of which was selected at step **1201** and said guide node is referenced within database **506**, whereby the corresponding guide layer generated in the 3-D compositing environment inherits the geometry and the RCS of said selected scene object at step **1303**.

Thus, in effect, the guide layer is generated within the three-dimensional compositing environment with the same geometric centre as said selected object and the same screen RCS, world RCS, parent RCS and local RCS co-ordinates, whereby any subsequent interaction by the

artist of a parent object of said selected object propagates the corresponding transformation to the geometry and geometric centre of said guide layer.

Figure 14

The positioning of the guide layer generated according to steps **1301** to **103** at step **1205** is further described in *Figure 14*.

At step **1401**, the user input data input by the artist by means of keyboard **105**, mouse **106**, stylus **102** with tablet **103** or any combination thereof, is constrained to two-dimensional data only, i.e. the steps (Z) co-ordinate a value of the geometric centre of the guide layer is clamped to its current value in the currently selected RCS and corresponding clamped in the conformation matrices if the artist were to select alternative RCS's **707** to **710** prior to generating the new layer at step **1206**. Consequently, upon artist **100** selecting the guide layer within display portion **701** for manipulation therein by means of pointer **711**, application **502** processes the X input data, Y input data and the Z co-ordinate value clamped at unity with respective mR, mT, mS1 and ms2 transformation matrices at step **1402**, wherein said guide layer may only be manipulated along the XY plane of its local RCS, e.g. the XY plane of its parent RCS.

A question is asked at step **1403** as to whether further guide layer positioning input has been received. If the question of **1403** is answered positively, control returns to step **1402**, wherein said two-dimensional input data translates said guide layer alongside said XY plane and so on and so forth. Alternatively, if the question of step **1403** is answered positively, signifying that the artist has complete the guide positioning step **1205**.

Figure 15

The step **1206** of generating a new layer is further described in *Figure 15.*

Irrespective of whether the artist has generated a guide layer at step **1204** and positioned it at step **1205** according to the present invention, at step **1501** said user selects a new layer or a new tool, for instance respectively by means of positioning pointer **711** over layer widget **715** and activating a mouse button or pressing a hot key or tapping stylus **102** on tablet **103**, or by means of positioning pointer **711** over tool widget **716** and, similarly, effecting a mouse click or pressing a hot key or again, tapping stylus **102** on tablet **103**.

At step **1502**, a new scene graph node is created as a temporary child of the guide node created at step **1302** if a guide node was generated at step **1204** or, alternatively, said new scene graph node is created as a node of the scene graph selected at step **801**, whereby it is registered in database **506** like the guide node at step **1302**.

At step **1503**, the three-dimensional object corresponding to the layer or tool selected at step **1501** and registered within the scene graph at step **1502** inherits the RCS of its parent, which is the guide layer if it was generated according to steps **1301** to **1303** or the world RCS of the scene graph selected at **801** if said guide was not generated.

Figure 16

The positioning of the guide layer generated according to steps **1301** to **103** at step **1205** is further described in *Figure 14.*

At step **1601**, the user input data input by the artist by means of keyboard **105**, mouse **106**, stylus **102** with tablet **103** or any combination

thereof, is constrained to two-dimensional data only, i.e. the steps (Z) co-ordinate a value of the geometric centre of the guide layer is clamped to its current value in the currently selected RCS and corresponding clamped in the conformation matrices if the artists were to select alternative RCS's **707** to **710** prior to generating the new layer at step **1206**. Consequently, upon the artist selecting the new layer or tool within display portion **701** for manipulation therein by means of pointer **711**, application **502** processes the X input data, Y input data and the Z co-ordinate value clamped at unity with respective mR, mT, mS1 and mS2 transformation matrices at step **1602**, wherein said new layer or tool may only be manipulated along the XY plane of its local RCS, e.g. the XY plane of its parent RCS.

A question is asked at step **1603** as to whether further input data has been received to position the new layer or tool. If the question of **1603** is answered positively, control returns to step **1602**, wherein said two-dimensional input data translates said new layer or tool layer alongside said XY plane and so on and so forth. Alternatively, if the question of step **1603** is answered positively, signifying that the artist has completed the new layer or tool positioning step **1205**.

Figure 17

The scene graph of the example first described in *Figure 9* is shown in *Figure 17* wherein a guide layer was generated and registered therein according to step **1302** and a new layer subsequently generated a temporary child thereof according to step **1502**.

Referring back to *Figure 10*, the artist is satisfied with the pose of image frame **1002** and the pose of camera object **1001** within the 3-D compositing environment and now requires to generate a new layer within

said environment, which is the presenter foreground image frame to be composited within the screen display area of the TV set shown in image frame **508** as described in *Figure 11*.

According to the present invention, said artist selects the guide tool at step **1301** by means of positioning point **711** over the guide widget **717** and effects a mouse click, whereby a guide node **1701** is generated within scene graph **503**, **504** as a child of the background image frame object **1002** said artist selected at step **1201**, whereby said child dependency is shown at **1702**.

The guide layer **507** output by guide node **1701** inherits the geometry and RCS of object **1002**, thus the guide object generated within the 3-D compositing environment is not only a child of object **1002** but also a child of camera object **1001**.

Upon completing the positioning step **1205**, the artist subsequently selects the layer tool, for instance by means of translating pointer **711** over the layer widget **716** and effecting a mouse click, wherein a node **1703** is created within scene graph **503**, **504** as a frame node outputting an image frame **508** as a child of guide node **1701**, shown at **1704**.

Frame node **904** is defined within scene graph as a child of rendering node **903** and guide node **1701** is similarly defined within said scene graph as a child node of said rendering node **903**, as it is itself a child of frame node **904**. Similarly, frame node **1703** is a child of rendering **903**, as it is itself a child of guide node **1701**. The temporary nature of said guide node **1701** however, ensures that any layer or tool positioned in relation to the 3-D object **1002** representing frame node **904**, such as frame node **1703**, does not necessarily remain a child node thereof from the moment of its inception thereon. Indeed, the image frame data **508** output

by frame node **1703** may require additional colour correction from a colour correction node **1705** providing the same functionality as colour correction **905** independently of the colour correction applied by said colour correction node **905** to the image frame data **508** output by frame node **904**. In this situation, it would therefore be preferable for frame nodes **904** and **1703** to be respectively children of a rendering node **903** but unrelated themselves.

In order to satisfy this condition, said guide node is temporary in the sense that it only remains in scene graph **503**, **504** so long as the artist requires its usability for positioning objects within the 3-D compositing environment, whereby upon completing the alignment of the new layer generated from said frame node **1703** within said 3-D compositing environment, the artist can subsequently again select said guide layer by means of pointer **711** and simply delete it, for instance by means of pressing the "Delete" key of keyboard **105**, whereby hierarchical relationships **1702**, **1704** are similarly deleted.

Figure 18

The graphical user interface of application **502** according to the present invention is shown in *Figure 18*, having a 3-D compositing environment within which a guide layer was generated and the artist positions a new foreground image frame layer therewith.

The camera object **1001** and the background TV set image layer **1002** are shown within the 3-D compositing environment defined by RCS **304** and screen RCS **301** as shown in *Figure 10*. In accordance with the description of the present invention, the artist has positioned pointer **711** over background image layer **1002** for selection according to step **1201**, then positioned said pointer **711** over guide widget **717** and effected a

mouse click, whereby a reference pose layer **1801** was generated within said 3-D compositing environment as inheriting the geometry, geometric centre and RCS of background TV set layer **1002**. Said reference pose layer **1801** is shown slightly front of said background layer **1002** relative to camera object **1001** for the purpose of not obscuring the drawing unnecessarily but it will be understood that, in accordance with the description of the present embodiment, said layer has the same layer screen, world, parent and local co-ordinate as said object **1002**, in accordance with layer generating step **1204**.

Upon generating frame node **1703** within scene graph **503**, **504**, application **502** outputs the foreground TV presenter image layer **1101** which inherits the geometric centre and RCS of guide layer **1801** and, having constrained transformation of foreground layer **1101** in the depth (Z) dimension according to step **1801**, the artist may now select said foreground layer **1101** by means of pointer **711** and translate said new layer **1111** relative to the RCS of guide layer **1801**, i.e. background **1002**, relative to the RCS of said guide layer **1801**, i.e. relative to the RCS **1005** of said background layer **1002**. The artist can therefore very simply and effectively translate foreground frame **1101** along the vertical axis **1802** and/or the horizontal axis **1803** of said RCS **1005** only in relation to the frustrum of camera object **1001**, as would be the case in a traditional 2-D compositing environment with which said compositing artist is most proficient.

Claims

1. Apparatus for generating image data comprising memory means, display means, user input means and processing means, wherein said memory means stores said image data and instructions and said instructions configure said processing means to perform the steps of

defining first image data as a first layer having respective co-ordinates within a three-dimensional volume configured with a reference co-ordinate system;

in order to position second image data relative to said first image data within said volume, generating a reference pose layer and configuring the co-ordinates thereof as a second reference co-ordinate system within said volume;

positioning said reference pose layer relative to said first layer; and

upon selecting said second image data, defining said second image data as said second layer having respective co-ordinates within said three-dimensional volume configured with said second reference co-ordinate system.

2. A method of generating image data comprising the steps of

defining first image data as a first layer having respective co-ordinates within a three-dimensional volume configured with a reference co-ordinate system;

in order to position second image data relative to said first image data within said volume, generating a reference pose layer and configuring the co-ordinates thereof as a second reference co-ordinate system within

said volume;

positioning said reference pose layer relative to said first layer; and

upon selecting said second image data, defining said second image data as said second layer having respective co-ordinates within said three-dimensional volume configured with said second reference co-ordinate system.

3. A computer-readable medium having instructions for generating image data stored thereon, wherein when said instructions are processed by a computer configured with memory means storing said image data, display means, user input means and processing means, said instructions configure said processing means to perform the steps of

defining first image data as a first layer having respective co-ordinates within a three-dimensional volume configured with a reference co-ordinate system;

in order to position second image data relative to said first image data within said volume, generating a reference pose layer and configuring the co-ordinates thereof as a second reference co-ordinate system within said volume;

positioning said reference pose layer relative to said first layer; and

upon selecting said second image data, defining said second image data as said second layer having respective co-ordinates within said three-dimensional volume configured with said second reference co-ordinate system.

4. A computer programmed to generate image data, said computer includes memory means, display means, user input means and

processing means, wherein said memory means stores said image data and instructions and said instructions configure said processing means to perform the steps of

defining first image data as a first layer having respective co-ordinates within a three-dimensional volume configured with a reference co-ordinate system;

in order to position second image data relative to said first image data within said volume, generating a reference pose layer and configuring the co-ordinates thereof as a second reference co-ordinate system within said volume;

positioning said reference pose layer relative to said first layer; and

upon selecting said second image data, defining said second image data as said second layer having respective co-ordinates within said three-dimensional volume configured with said second reference co-ordinate system.

Abstract of the Disclosure

Three-Dimensional Compositing

An apparatus **101** for generating image data is provided which comprises memory means **207**, display means **104**, user input means **102**, **103**, **105**, **106** and processing means **201**, **202**, wherein said memory means stores said image data **503**, **504** and instructions **502** and said instructions configure said processing means to perform the steps of defining first image data **904**, **508** as a first layer **1002** having respective co-ordinates within a three-dimensional volume **701** configured with a reference co-ordinate system **304**; upon selecting second image data **1703** as a second layer **1101** to composite with said first layer, generating (**1204**) a reference pose layer **1801** and configuring the co-ordinates thereof as a second reference co-ordinate system **1005** within said volume **701**; positioning (**1205**) said reference pose layer **1801** relative to said first layer **1002**; and defining (**1206**) said second image data **1703** as said second layer **1101** having respective co-ordinates within said three-dimensional volume **701** configured (**1205**, **1206**) with said second reference co-ordinate system **1005**.

(Figure 12)

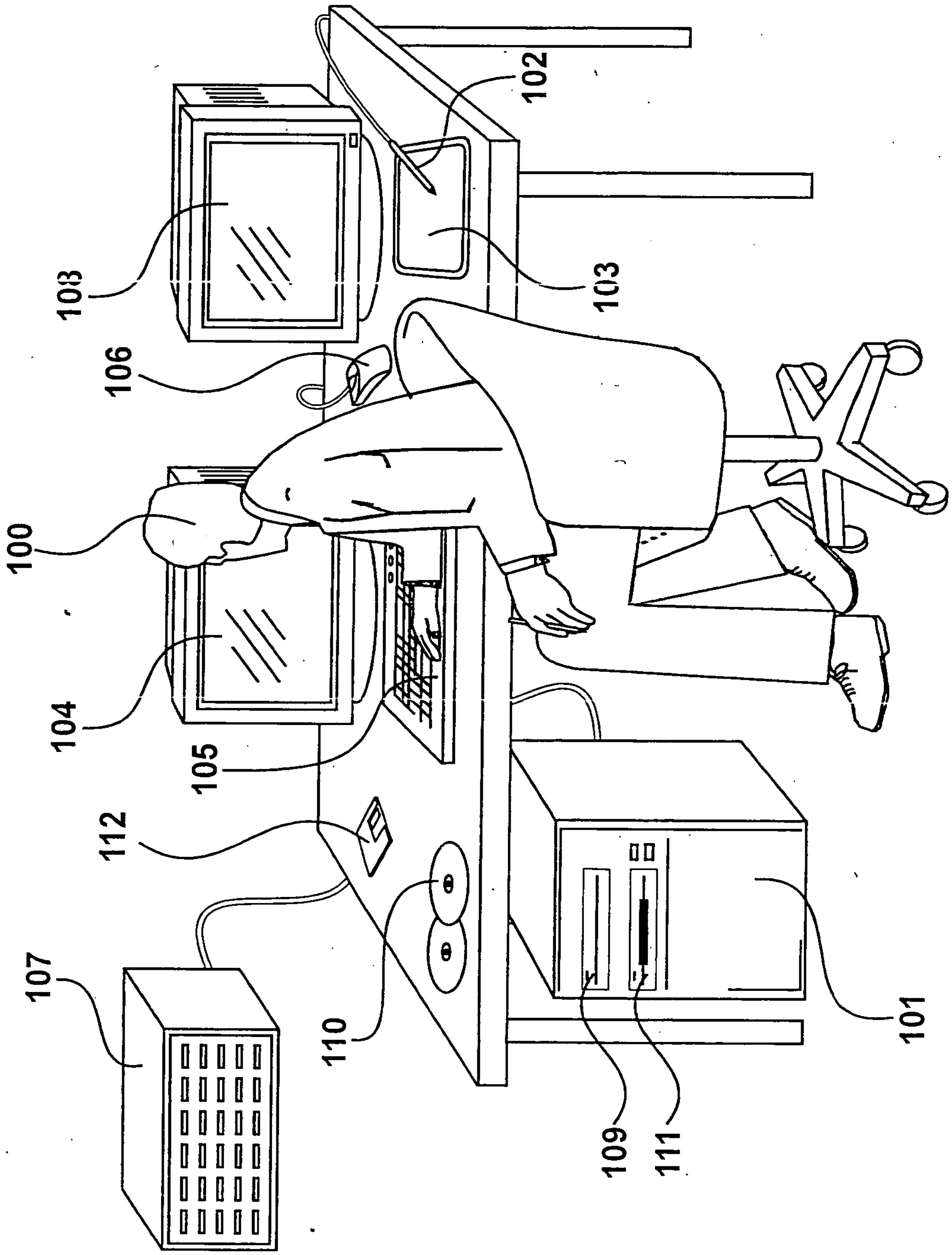

Figure 1

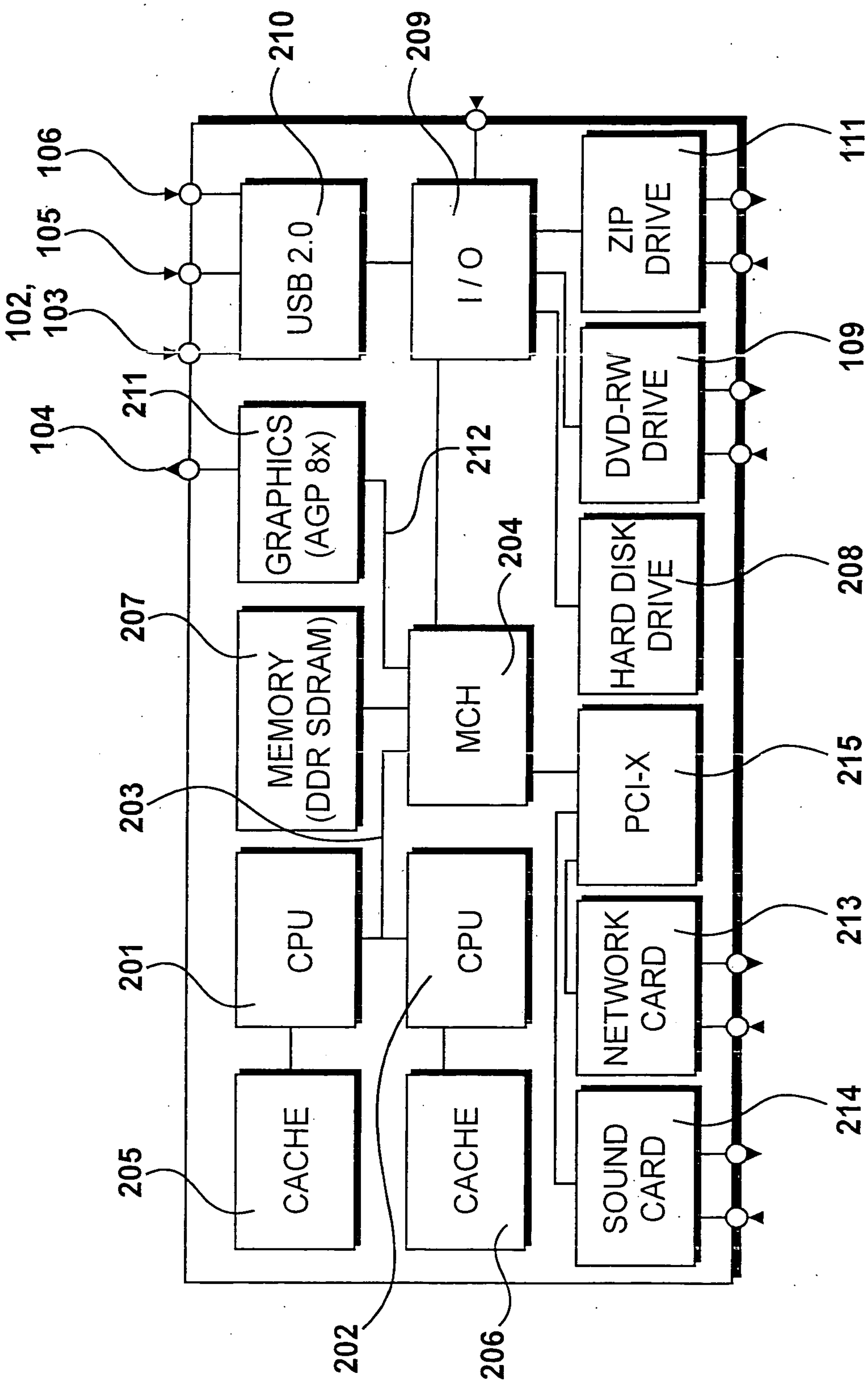
USB 2.0
I / O
ZIP DRIVE
DVD-RW DRIVE
GRAPHICS (AGP 8x)
HARD DISK DRIVE
MEMORY (DDR SDRAM)
MCH
PCI-X
CPU
CPU
NETWORK CARD
CACHE
CACHE
SOUND CARD
210
209
106
105
102, 103
111
211
104
212
109
204
207
208
203
215
201
213
205
214
202
206

Figure 2

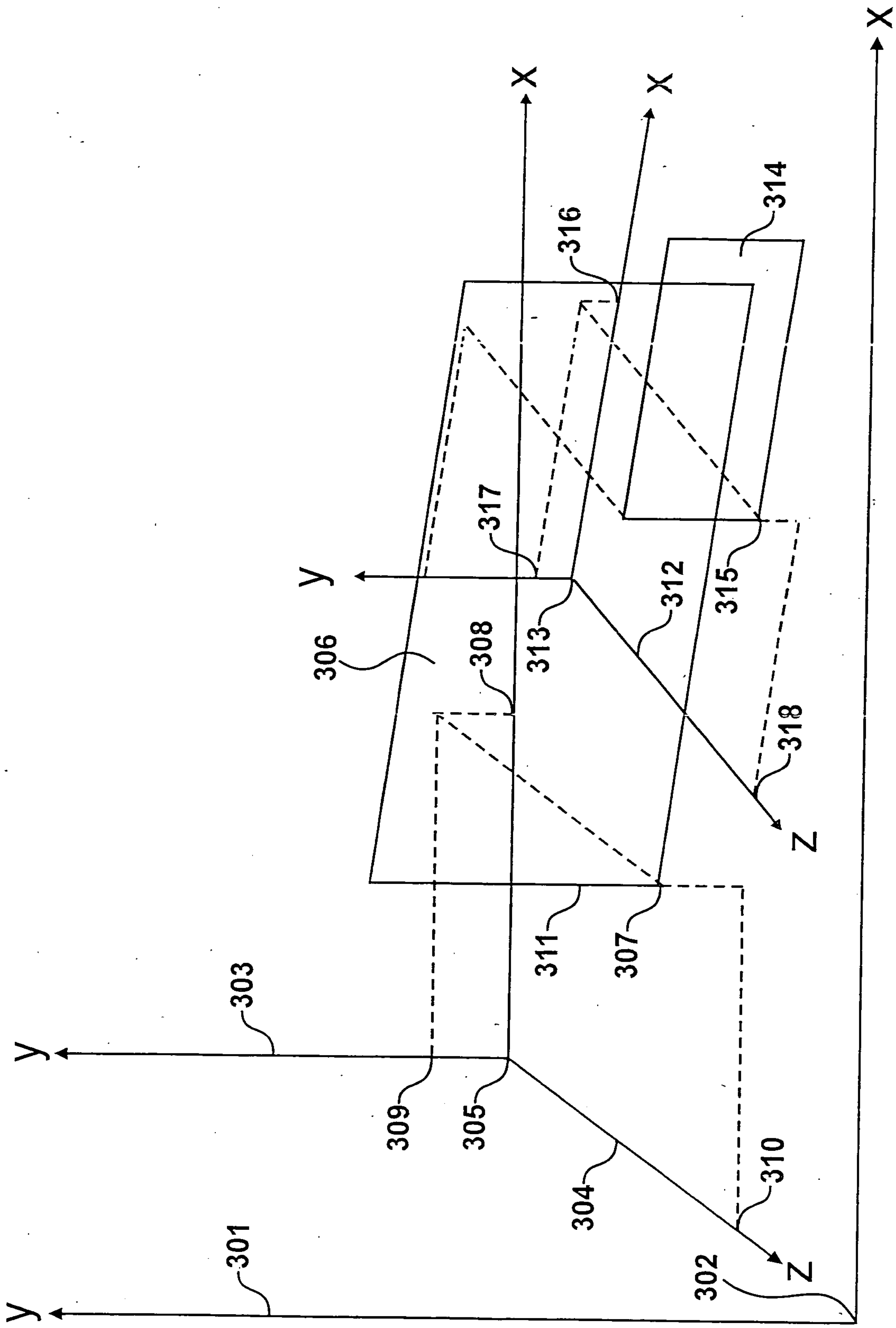
x
x
x
y
y
y
z
z
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318

Figure 3

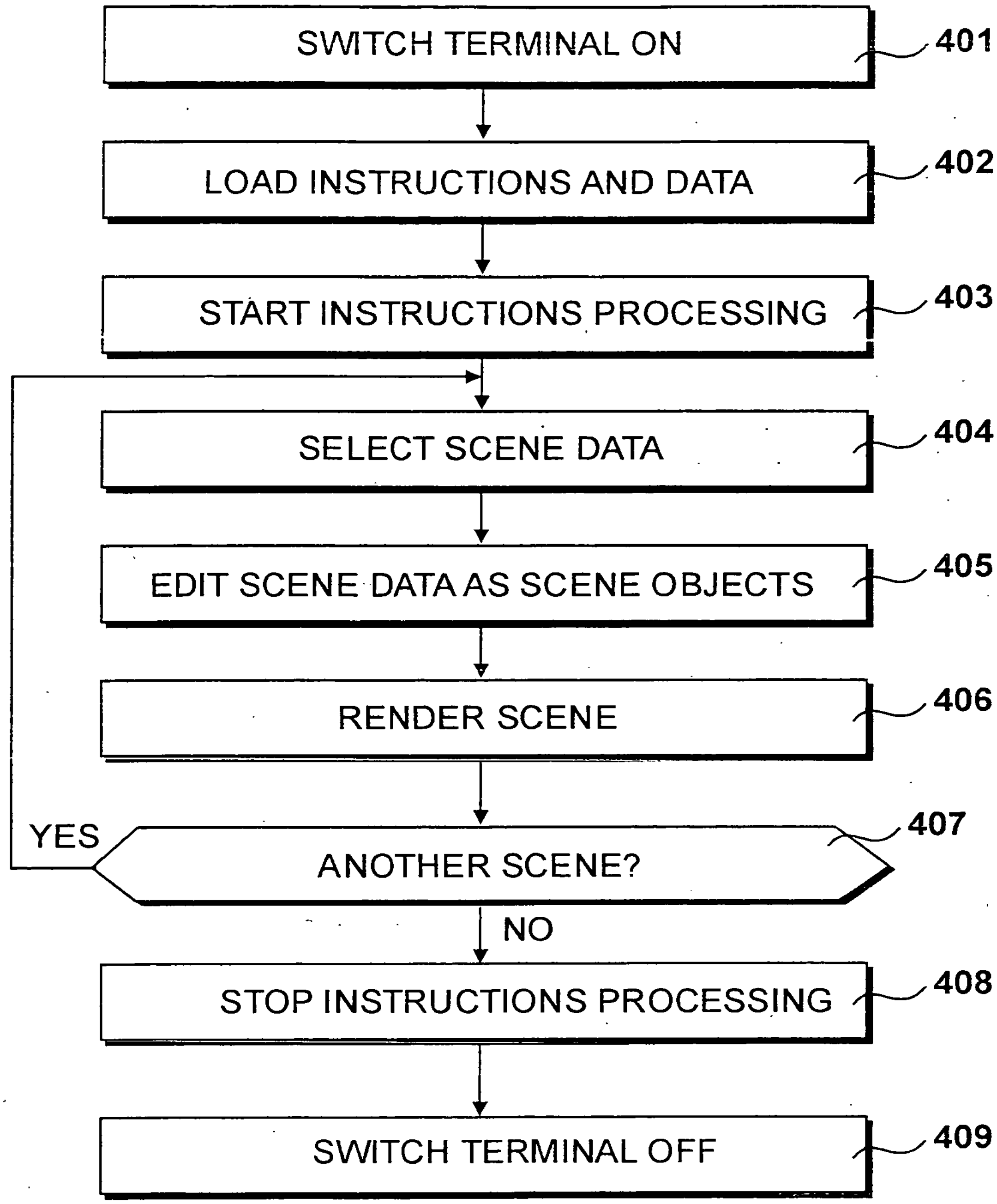
SWITCH TERMINAL ON
401
LOAD INSTRUCTIONS AND DATA
402
START INSTRUCTIONS PROCESSING
403
SELECT SCENE DATA
404
EDIT SCENE DATA AS SCENE OBJECTS
405
RENDER SCENE
406
YES
ANOTHER SCENE?
407
NO
STOP INSTRUCTIONS PROCESSING
408
SWITCH TERMINAL OFF
409

Figure 4

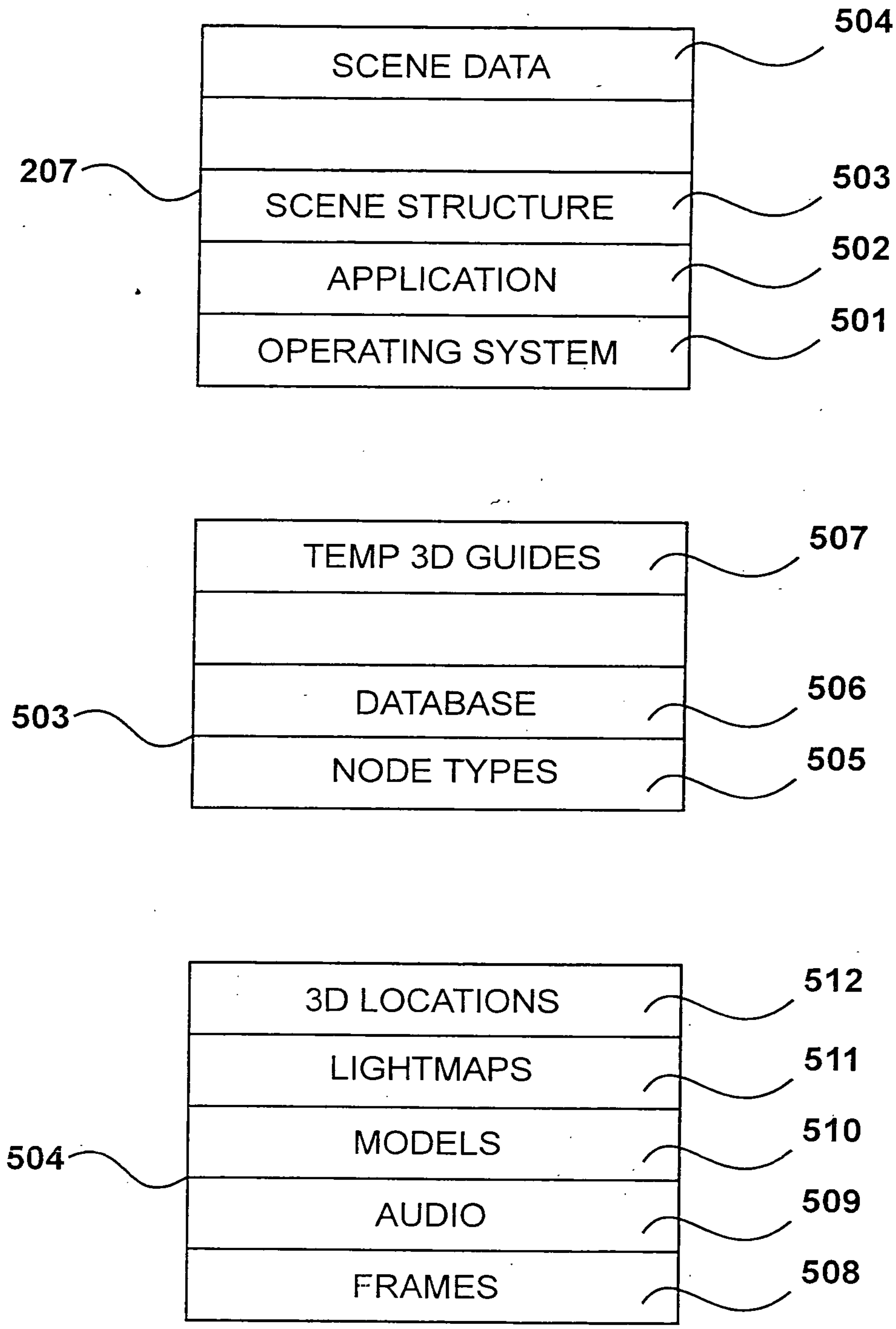
504
SCENE DATA
207
503
SCENE STRUCTURE
502
APPLICATION
501
OPERATING SYSTEM
507
TEMP 3D GUIDES
503
506
DATABASE
505
NODE TYPES
512
3D LOCATIONS
511
LIGHTMAPS
510
MODELS
504
509
AUDIO
508
FRAMES

Figure 5

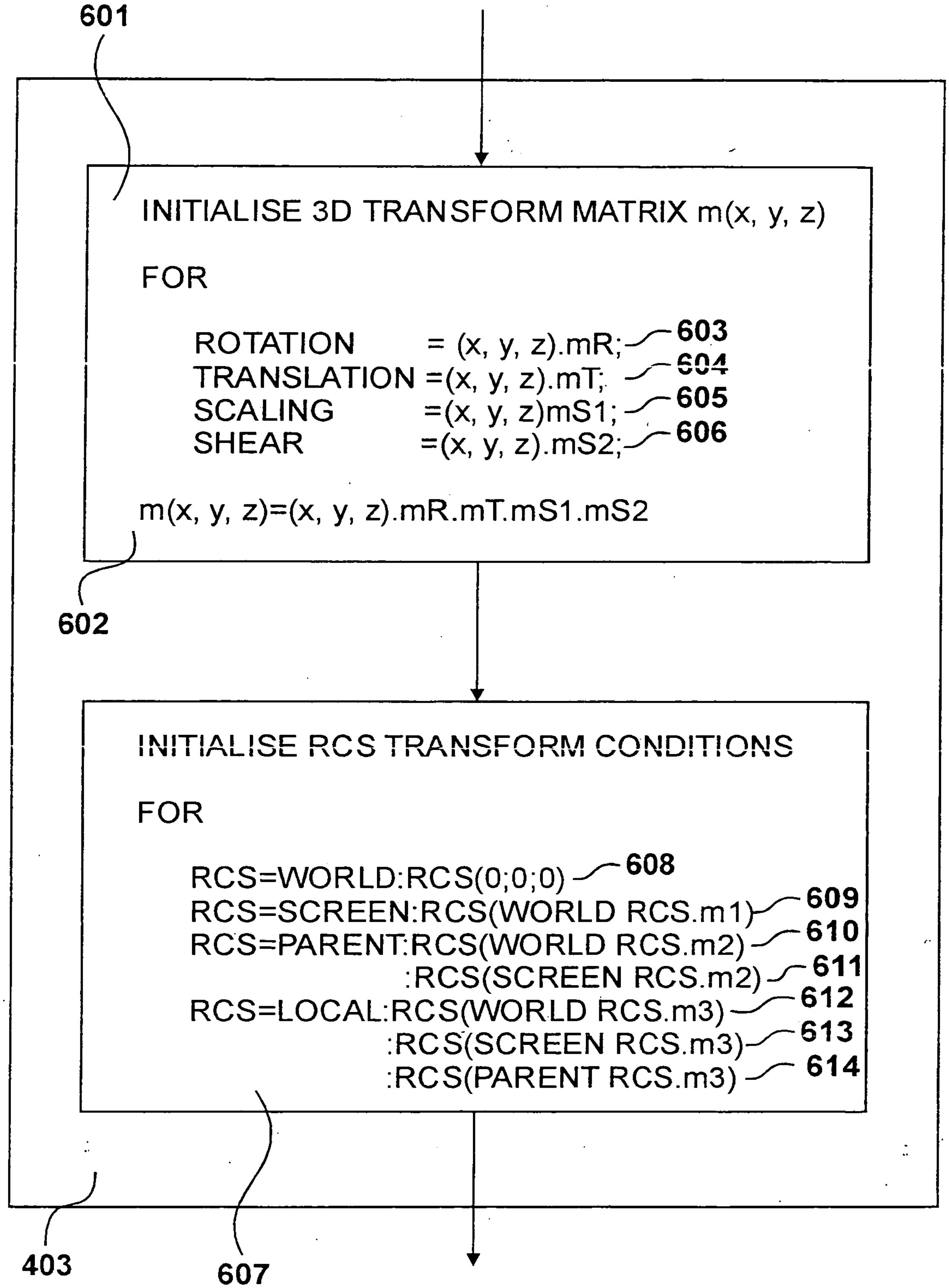
601
INITIALISE 3D TRANSFORM MATRIX m(x, y, z)
FOR
ROTATION = (x, y, z).mR;
603
TRANSLATION =(x, y, z).mT;
604
SCALING =(x, y, z)mS1;
605
SHEAR =(x, y, z).mS2;
606
m(x, y, z)=(x, y, z).mR.mT.mS1.mS2
602
INITIALISE RCS TRANSFORM CONDITIONS
FOR
RCS=WORLD:RCS(0;0;0)
608
RCS=SCREEN:RCS(WORLD RCS.m1)
609
RCS=PARENT:RCS(WORLD RCS.m2)
610
:RCS(SCREEN RCS.m2)
611
RCS=LOCAL:RCS(WORLD RCS.m3)
612
:RCS(SCREEN RCS.m3)
613
:RCS(PARENT RCS.m3)
614
403
607

Figure 6

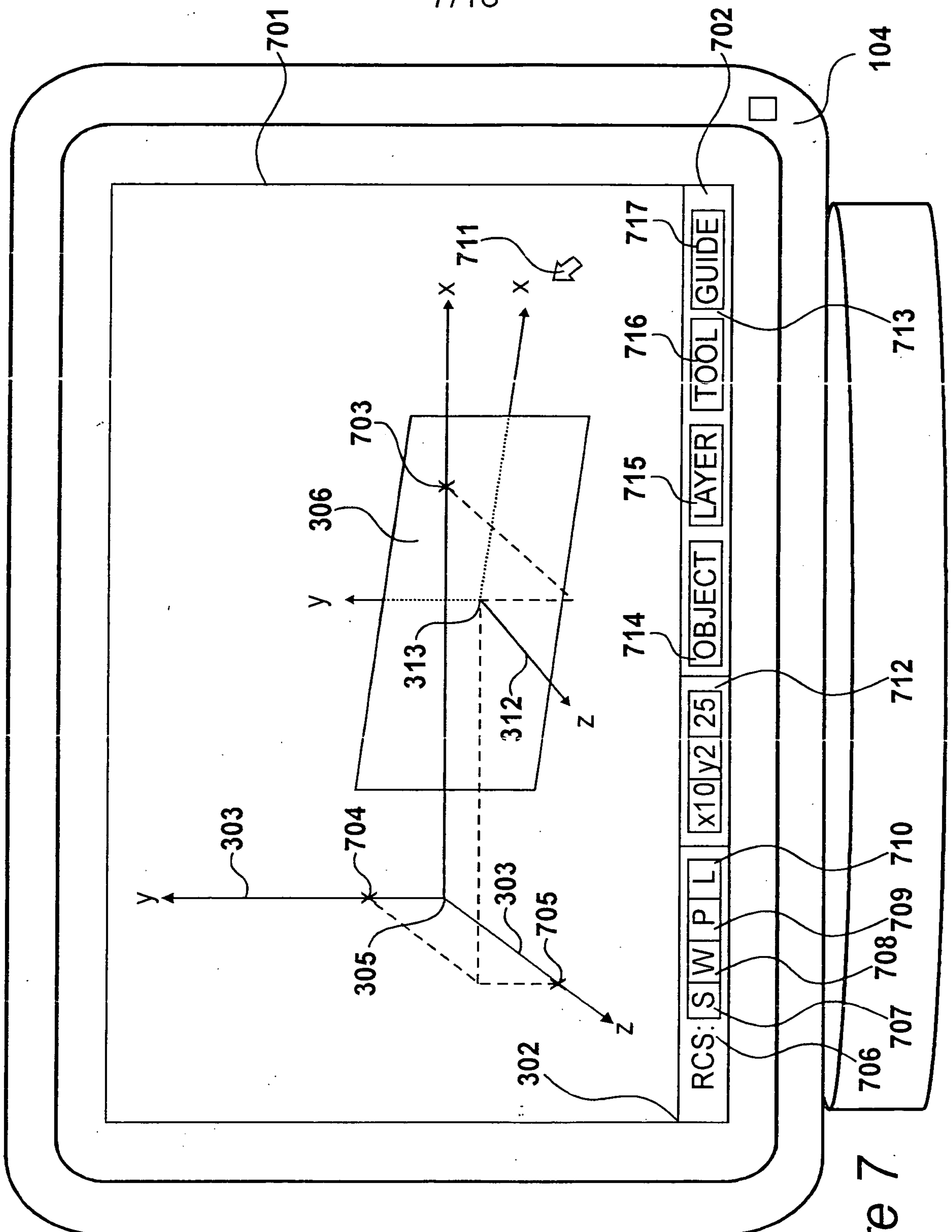
701
702
104
711
x
x
y
y
z
z
703
306
313
312
303
303
704
305
705
302
RCS:
S
W
P
L
x10
y2
25
OBJECT
LAYER
TOOL
GUIDE
706
707
708
709
710
712
713
714
715
716
717

Figure 7

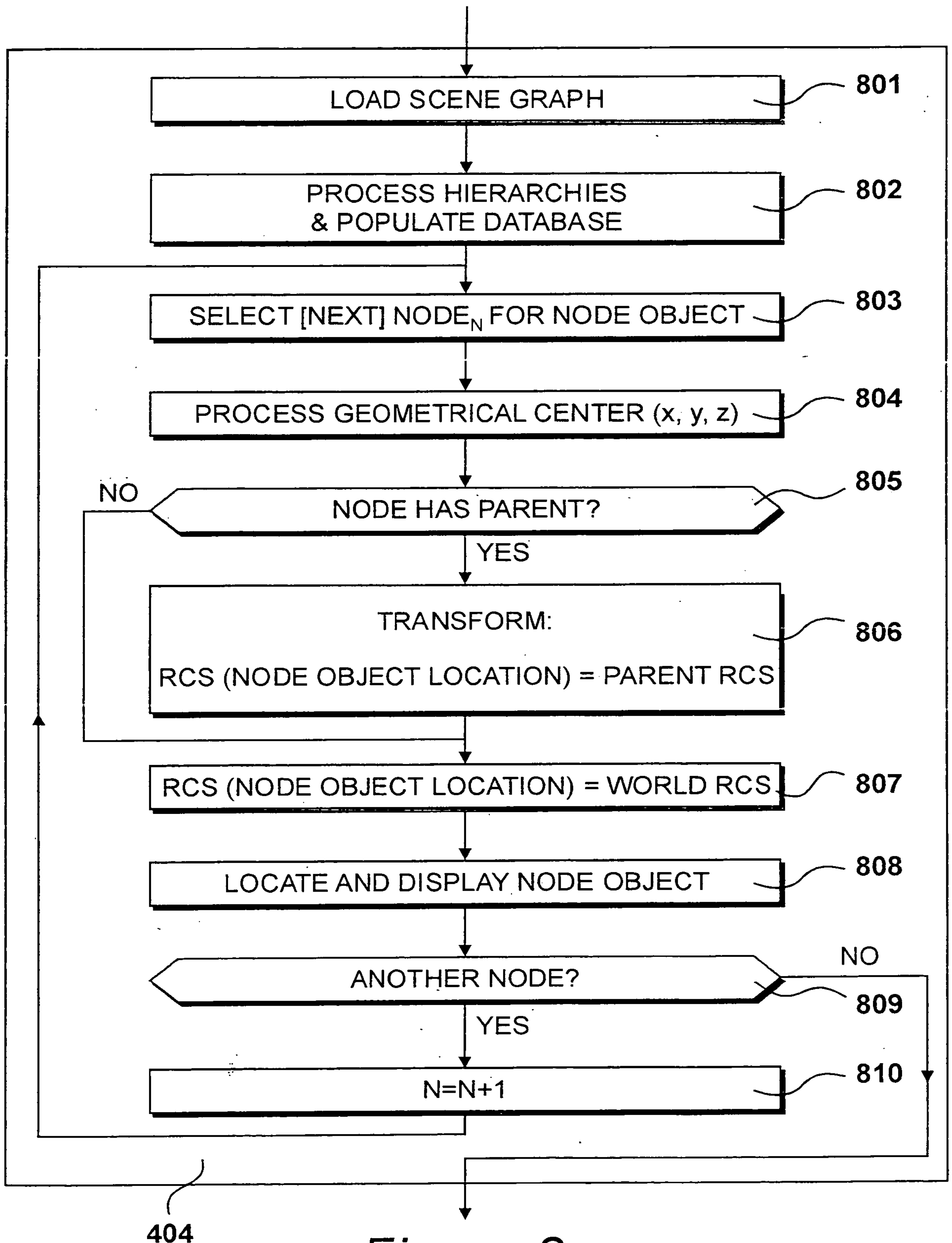
LOAD SCENE GRAPH
801
PROCESS HIERARCHIES & POPULATE DATABASE
802
SELECT [NEXT] NODE$_N$ FOR NODE OBJECT
803
PROCESS GEOMETRICAL CENTER (x, y, z)
804
NODE HAS PARENT?
805
NO
YES
TRANSFORM:
RCS (NODE OBJECT LOCATION) = PARENT RCS
806
RCS (NODE OBJECT LOCATION) = WORLD RCS
807
LOCATE AND DISPLAY NODE OBJECT
808
ANOTHER NODE?
NO
809
YES
N=N+1
810
404

Figure 8

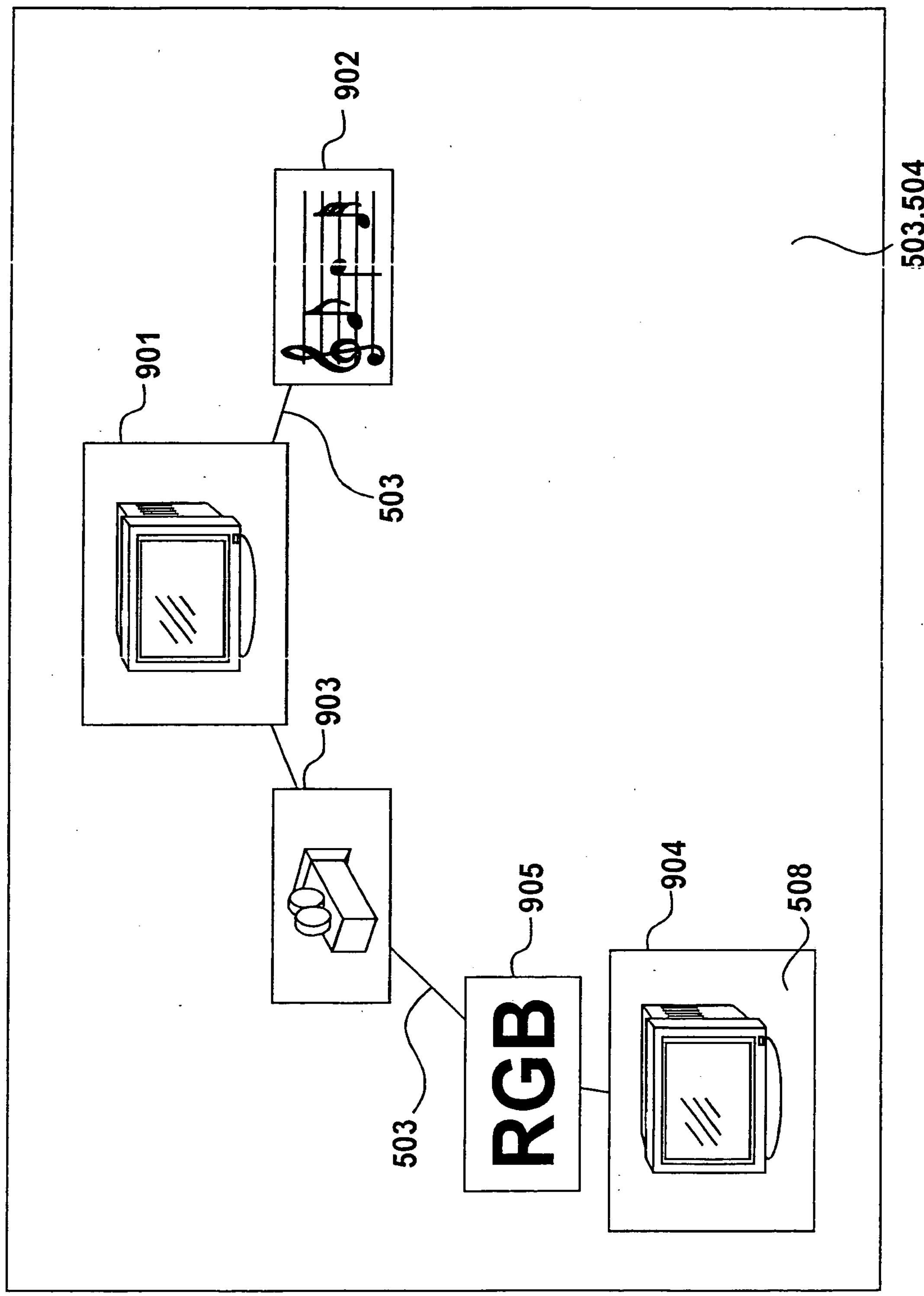

Figure 9

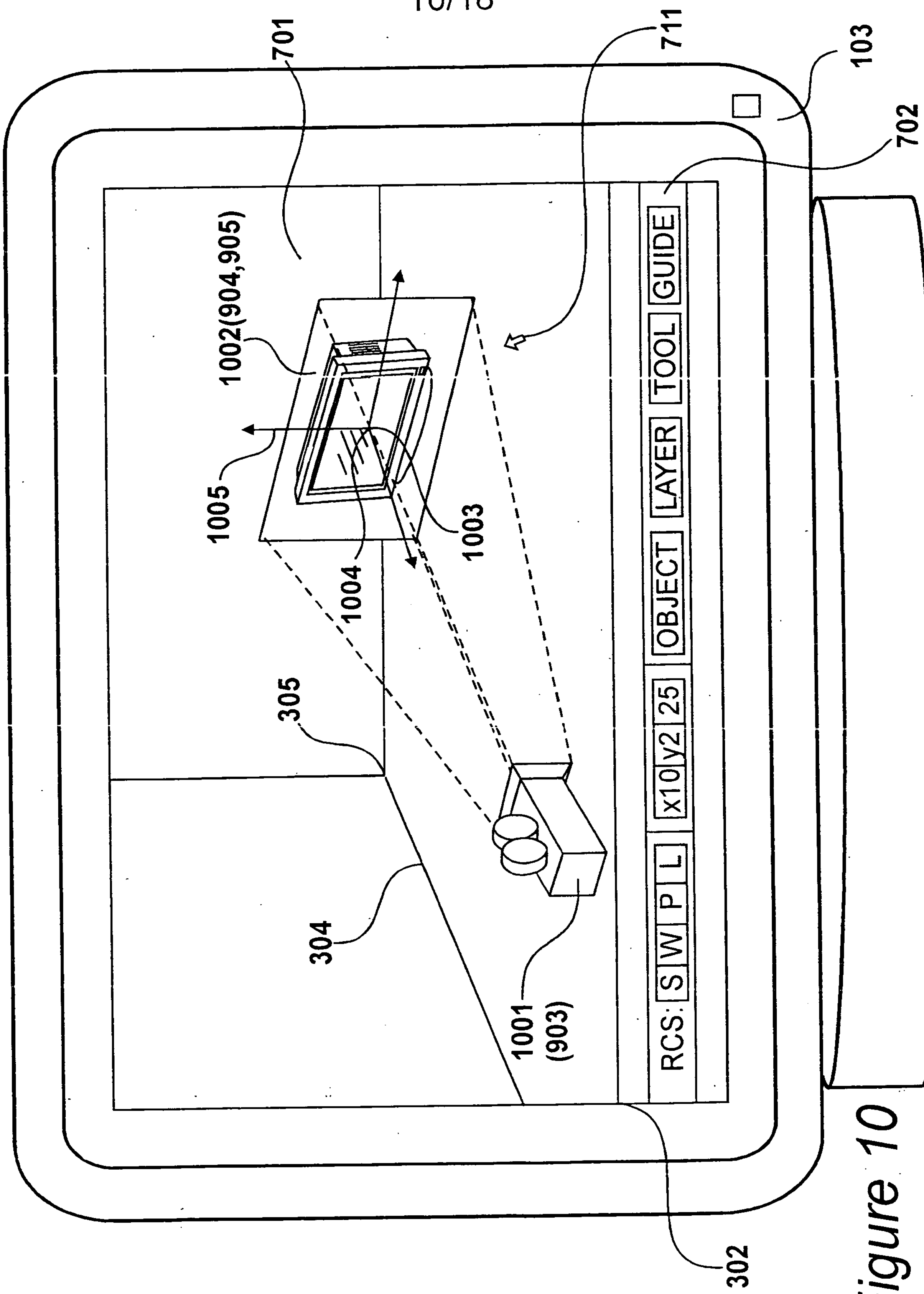
701
711
103
702
1002(904,905)
1005
1003
1004
305
304
1001
(903)
302
RCS: S W P L
x10 y2 25
OBJECT
LAYER
TOOL
GUIDE

Figure 10

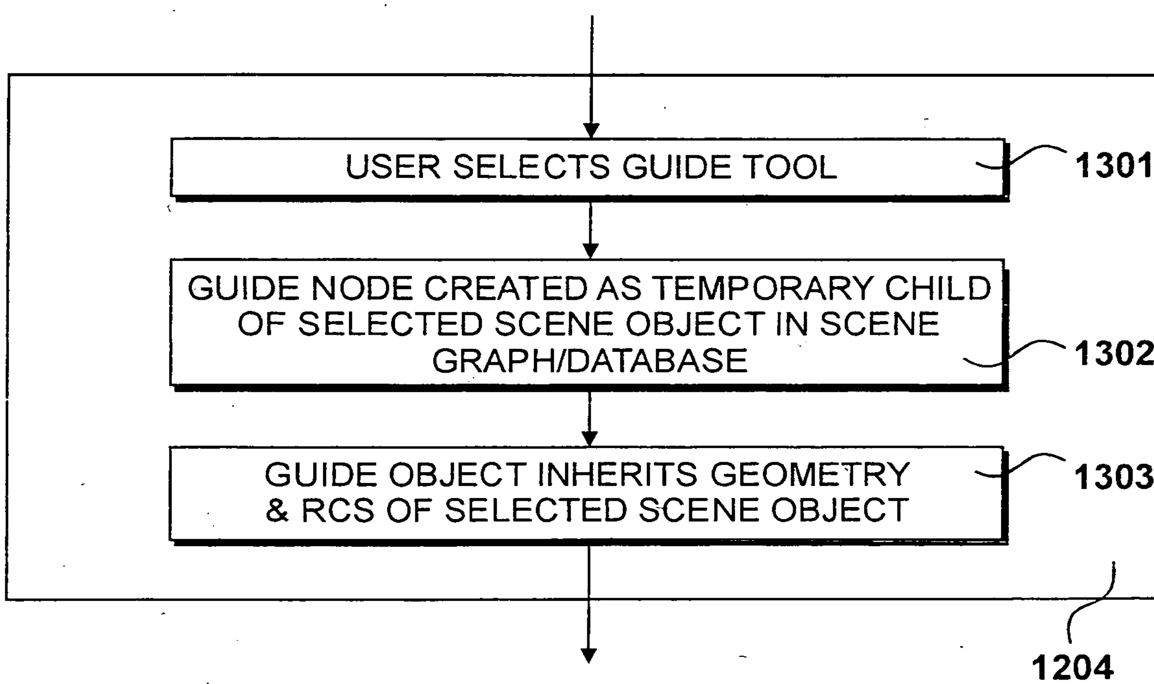
USER SELECTS GUIDE TOOL
1301
GUIDE NODE CREATED AS TEMPORARY CHILD OF SELECTED SCENE OBJECT IN SCENE GRAPH/DATABASE
1302
GUIDE OBJECT INHERITS GEOMETRY & RCS OF SELECTED SCENE OBJECT
1303
1204

Figure 13

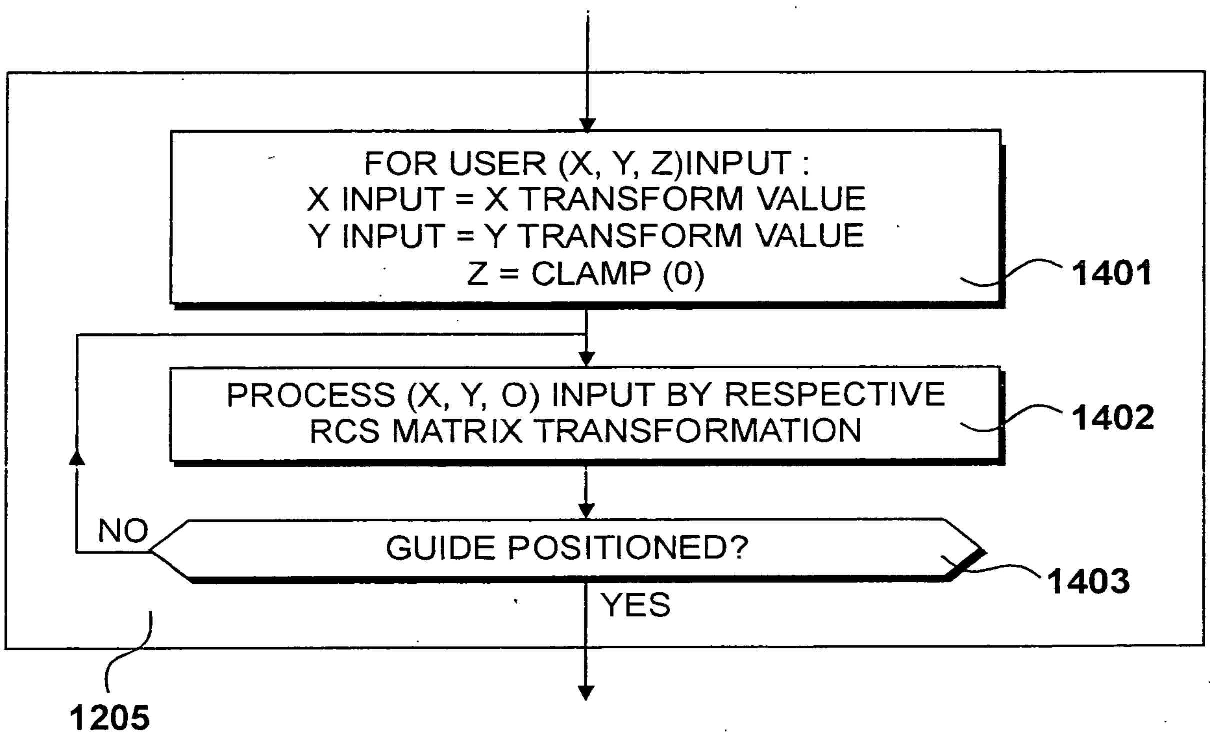
FOR USER (X, Y, Z)INPUT :
X INPUT = X TRANSFORM VALUE
Y INPUT = Y TRANSFORM VALUE
Z = CLAMP (0)
1401
PROCESS (X, Y, O) INPUT BY RESPECTIVE
RCS MATRIX TRANSFORMATION
1402
NO
GUIDE POSITIONED?
1403
YES
1205

Figure 14

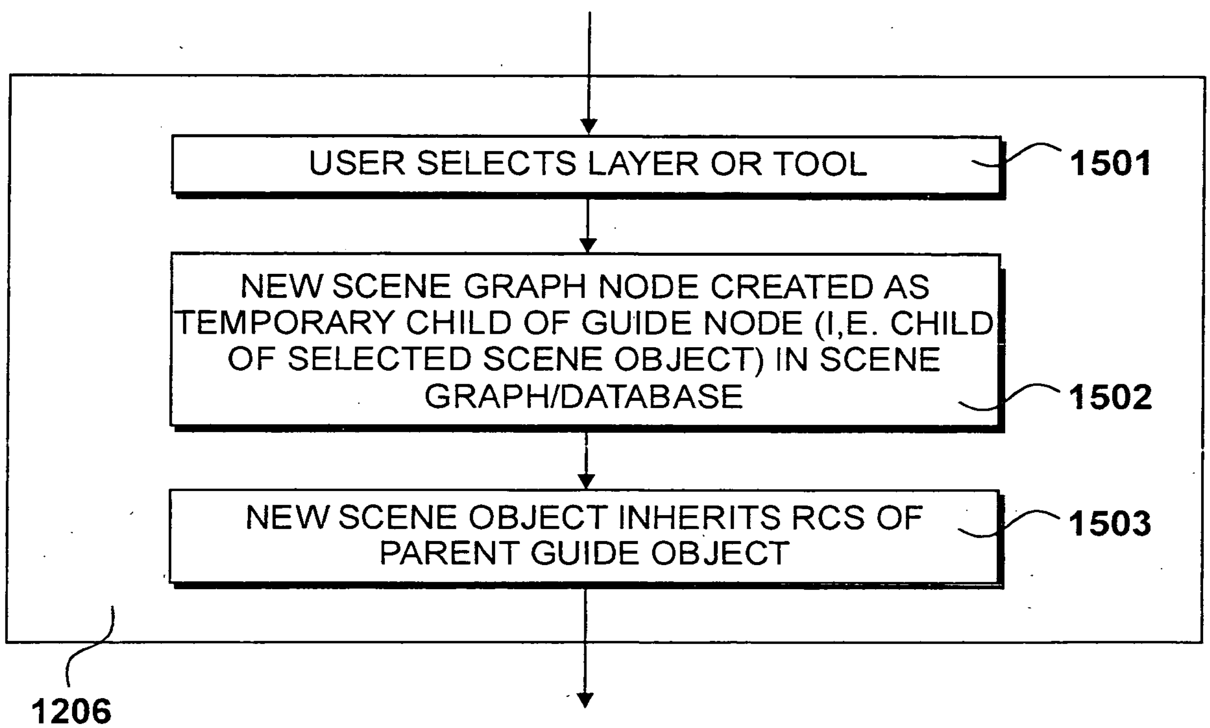
USER SELECTS LAYER OR TOOL
1501
NEW SCENE GRAPH NODE CREATED AS TEMPORARY CHILD OF GUIDE NODE (I,E. CHILD OF SELECTED SCENE OBJECT) IN SCENE GRAPH/DATABASE
1502
NEW SCENE OBJECT INHERITS RCS OF PARENT GUIDE OBJECT
1503
1206

Figure 15

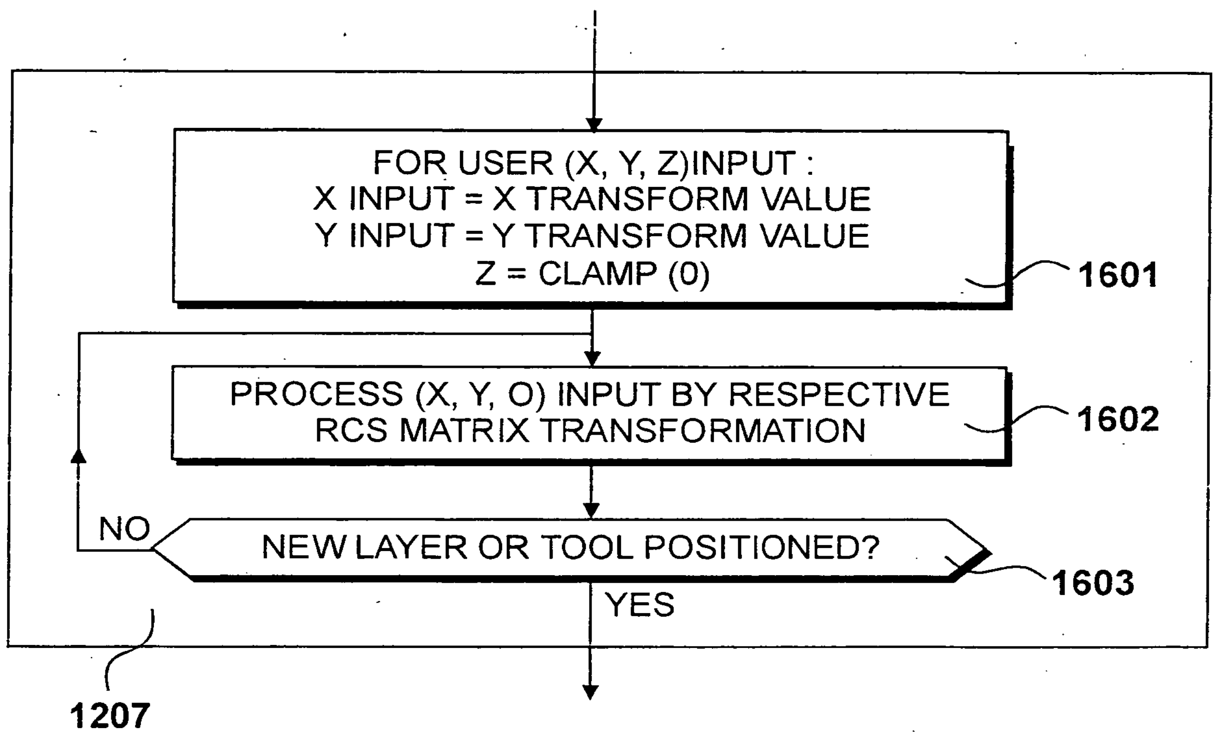
FOR USER (X, Y, Z)INPUT :
X INPUT = X TRANSFORM VALUE
Y INPUT = Y TRANSFORM VALUE
Z = CLAMP (0)
1601
PROCESS (X, Y, O) INPUT BY RESPECTIVE
RCS MATRIX TRANSFORMATION
1602
NO
NEW LAYER OR TOOL POSITIONED?
1603
YES
1207

Figure 16

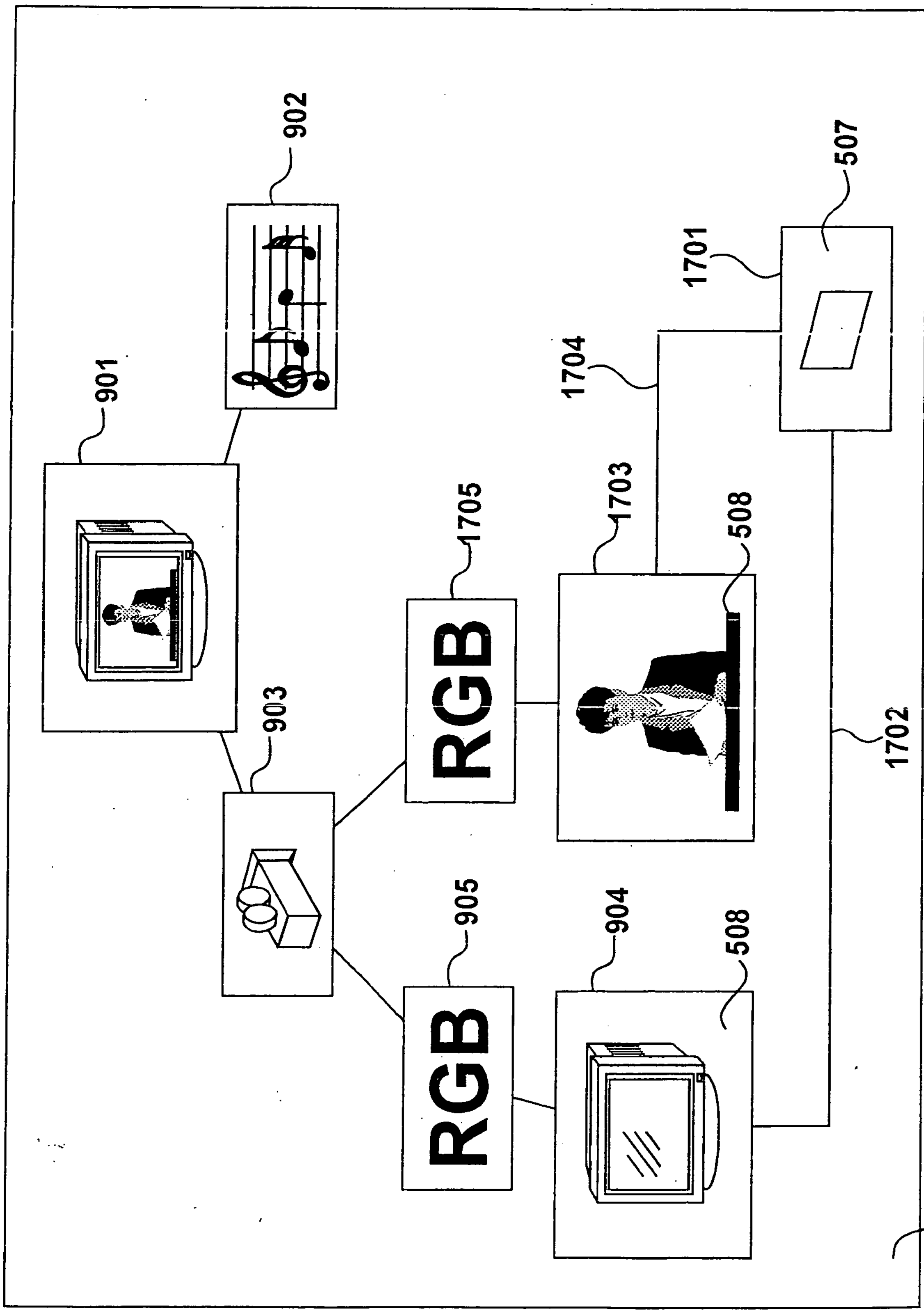
901
902
903
RGB
1705
RGB
905
904
1703
508
508
1704
1701
507
1702
503,504

Figure 17

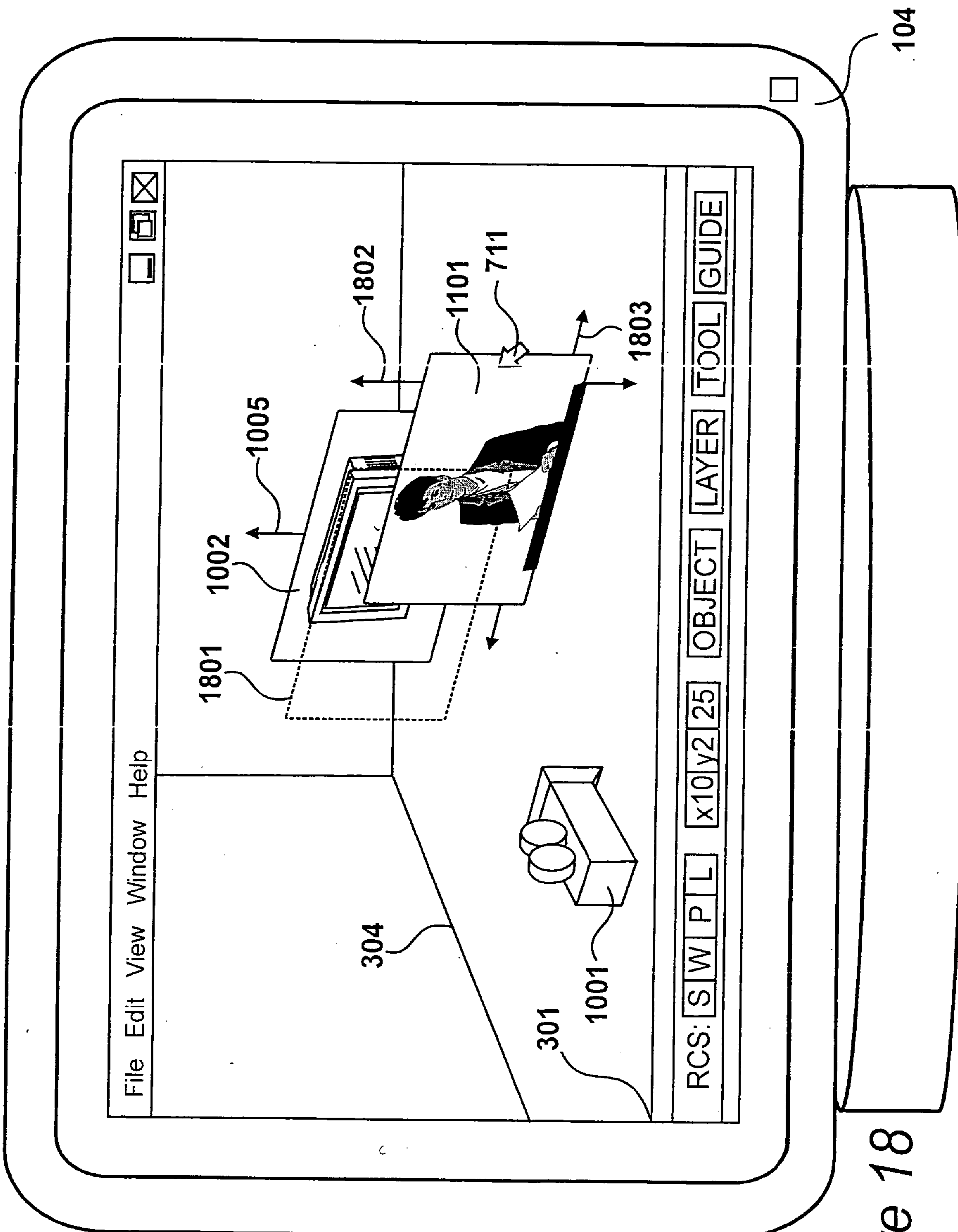
File Edit View Window Help
RCS: S W P L x10 y2 25 OBJECT LAYER TOOL GUIDE
104
1802
1101
711
1803
1005
1002
1801
304
1001
301

Figure 18